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Manhole Arc-Flash Testing
PCN 98954

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Manhole Arc-Flash Testing

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SCOPE OF WORK FOR

Manhole Arc-Flash Testing

Project Control Number (PCN): 98954

Fiscal Year (FY) – 2013

DATE: March 25, 2013

J. D. Muller TA-B3B
4/15/2013

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MANHOLE ARC-FLASH TESTING

1. SCOPE

1.1. IMPERATIVE FORM

1.1.1. This Scope of Work (SOW) is written in imperative form and this imperative language is directed to the general contractor, here after known as The Contractor, unless specifically noted otherwise.

1.2. DESCRIPTION

Provide services for electrical high power testing to determine the arc flash impact on cable splices inside a manhole/ vault to mimic the ground fault occurrences on KSC's 15kV power system. Provide all materials, labor, test lab services, support services, tools, equipment, sub-contracts, shipping, transportation, per-diem, and lodging to provide support services at both the Contractor's normal base of operation and an extended duration at the test lab location as specified herein. Procure, provide, prepare, install, connect, test, disconnect and remove cables, cable splices, manhole, cable termination to the test console, etc. as described in this SOW. Procurement of all items shall satisfy the requirements of KSC standard specifications attached to this scope of work. Testing shall occur at a laboratory specializing in such high current power testing. It is the responsibility of this services contractor to subcontract the testing services to a laboratory acceptable to the Government, coordinate the testing of cable splices, provide the test results as required by KSC and transport service items and personnel to the test laboratory and back.

1.2.1. ATTACHMENTS:

The following attachments are incorporated into the requirements of this statement of work as referenced:

1. Scope of Work for Manhole Arc-Flash Testing Laboratory Services
2. Document submittal register.
3. Test Circuit Diagram Sketch SKE-001
4. Manhole Detail Sketch SKE-002
5. Test Table
6. Wire fusing current calculation (1083 deg. C)
7. Wire fusing current calculation (2300 deg. C)
8. Excerpts from KSC Power Manhole Entry Safety Requirements
9. KSC Standard Specification For Medium Voltage Cable and Splice Photograph
10. Product data sheets for reference only.

1.2.2 TESTING OBJECTIVE

The primary objective of this testing is to determine, if such a condition exists, where the combination of reduced line to ground fault current level occurring at a splice within a manhole with a 6 cycle interrupting time significantly results in a reduced hazard to personnel who may be working within a manhole or cable

vault located at the Kennedy Space Center (KSC). If testing indicates a current level threshold significantly reduces risk, then KSC will pursue a project to install neutral resistors on its Substation transformers to limit fault current accordingly. A secondary objective is to determine, through testing, the existing hazard risk within manholes with the present ground fault current levels and a 6-cycle interrupting time.

1.2.3. HIGH CURRENT AND VOLTAGE TEST LAB SERVICES

1.2.3.1. Subcontract test lab services for the project in accordance with the Attachment 1 Statement of Work entitled "SCOPE OF WORK FOR Manhole Arc-Flash Testing Laboratory Services."

Testing shall occur at one of the two laboratory sites below:

a. KEMA – Powertest LLC, Chalfont, PA.

b. Kinectrics – Toronto, Canada

Provide the test lab all statement of work documents and referenced attachments. Include in the submittals to the Government any changes or modifications to the division of work indicated in the support service and test laboratory statements of work.

Fully coordinate submittals, test assembly, test procedures, and safety plans with the test laboratory during all phases of the project.

Notify the Contracting Officer 60 calendar days minimum prior to test lab testing period. Up to three (3) Government representatives will witness the testing at the laboratory site.

Notify the Contracting Officer 21 calendar days prior to the coordination meeting with the testing laboratory held during the Government's inspection of the test assembly. A Government representative will attend this meeting.

1.3. STATEMENT OF WORK-SUPPORT SERVICES

1.3.1 SUPPORT SERVICES

a. The Contractor will be fully responsible for coordinating with the test lab, conduct the tests as specified herein, and provide the Government with the test results. The Contractor shall obtain any and all Government permits required for performing work at the laboratory site and travelling to and from the test laboratory site.

b. Include all labor, tools, materials, equipment, tools, transportation, per-diem, lodging, sub-contracts, and supervision to provide complete and turn-key services as identified in this scope of work.

c. Obtain a copy of the test laboratory's safety procedures and any other required operational or technical requirements. Provide all personal protective equipment necessary for working with medium voltage circuits at the Test Laboratory.

d. Submit all documents for the Governments review and approval as shown on the Attachment 2 Document Submittal Register.

e. Fabricate test assembly including but not limited to the sectionalizer cabinet, relay cabinet, manhole, PT cabinet, cables, and the initial faulted splice test specimens at the Contractor's facility.

f. At the Contractor's location, set up and connect everything to verify that nothing is missing. Government shall inspect the final product before shipping to test lab.

g. Coordinate a meeting at the Contractor's test assembly demonstration site with NASA and the testing laboratory before the test assembly is shipped to the laboratory. Review finalized safety test procedures and safety plans for the work at the laboratory site. Hold this meeting during the Government's visit to inspect the test assembly.

h. Transport all materials, tools and support personnel to the test lab and set up everything prior to testing.

i. Coordinate a pre-test meeting with NASA, the testing laboratory, and the contractor at the testing laboratory after the test assembly has been received at the laboratory to plan the sequence of testing and support requirements.

j. Provide all services required by the test lab during the testing. Contractor shall adequately staff and logistically support all activities at the testing laboratory to insure the maximum number of tests are performed.

k. Prepare and install test specimen splices, manikins, PPEs and instruments as and when required by the test lab.

l. Prepare and provide the test results for each test. The test table attached can be used as a base for identifying each test.

m. Disassemble test assembly and remove from the test laboratory site; recycle and dispose of all materials and equipment in accordance with Governmental regulations that is not returned to KSC.

n. Package and ship the following material to KSC as requested by the Government: protective relay and laptop computer, faulted splice sections, personnel protective equipment, arc-flash blankets, manikins, and unused splice kits.

1.3.2 SECTIONALIZING CABINET:

a. Reference Attachments 3 and 10.

b. Provide a single phase sectionalizing cabinet to provide a dead-front interface between test lab fault generating equipment and cable sections to be tested.

c. Provide three position 600-amp jumpers with connections as follows:

i) Incoming cables from fault generator; install SEL relay current transformers on these cables.

ii) Outgoing cables to potential transformer.

iii) Outgoing cables to manhole separable connector.

d. All separable connector and components equipment shall be 15kV, 600 Amp, dead break type and rated in accordance with IEEE 386.

e. Cut holes and provide bushings in cabinet as required for routing of cables to test equipment and manhole.

1.3.3 METERING AND RELAYING

a. Reference Attachments 3 and 4.

b. Provide (1) ABB Type VIZ-11 PT or equal with integral fuse clips and manufacturer's recommended fusing. Mount potential transformer within a wet location sectionalizing cabinet enclosure. Mount class CC pull-out fuse block for secondary fuse. Provide at least 2 sets of spare fuses for all types used.

c. Ground PT and CT secondary circuits to a suitable ground at the test site using a #10 AWG minimum copper cable.

d. Provide (1) 1200:5, C200 multi-ratio connected 600:5 current window current transformers and mount shorting type terminal blocks within the sectionalizing cabinet.

e. Install a Schweitzer SEL-751A relay with current, voltage, and digital trigger input in a wet location enclosure with swing out panel (Make all control power, trigger, and instrument transformer connections to the meter behind the interior door). Provide (1) laptop computer with EIA-232 port, software, and cables for setting up and retrieving data from the relay.

f. Route #10 AWG copper conductors from CT and PT secondary circuits to SEL relay using extra hard duty 600V power cord with the appropriate number of conductors.

g. Route SEL relay trigger circuit using cabling as required by the test laboratory.

1.3.4. CABLE

a. Reference Attachments 3, 4, 8, 9, and 10.

b. Cables shall be spliced and installed using the Attachment 9 KSC standard specification 26 05 13 00.98 and Attachment 10 data and instruction sheets. Concentric neutrals are to be connected together between the fault cable splice and the fault generator to serve as a fault return path. There are five different fault levels to be tested. Tests will be performed with and without a manikin. Manikin will have varying levels of PPE for each test. Tests will be carried out with or without an arc flash blanket just draped over the splices. Some tests may have to be repeated to evaluate the consistency of results. The attached test table shows the number of planned tests (32).

c. Fabricate and install the following test supply and instrumentation cables:

i) One 350 kcmil 15 kV concentric neutral cable and #4/0 AWG ground (insulated or bare per test laboratory requirements) from the test generator to the sectionalizer cabinet. Sectionalizer cabinet termination shall be 600 Amp dead-break elbow type. Connections to laboratory fault generator equipment shall be either live-front on dead-front as required by the test laboratory. Coordinate required cable length and connection type with the test laboratory. Label cables "Main-A" at each end. Provide and pre-fabricate (2) spare "Main-A" cables for contingency use at the test site.

ii) One #2 AWG, 15 kV, tape shield cable and #2 AWG ground from the sectionalizer cabinet to the PT cabinet. Sectionalizer cabinet termination shall be 200 Amp load-break elbow type. Terminations at the potential transformers shall be termination kits as required for the PT connections.

iii) Two conductor, #10 AWG extra hard usage wet location cord from the current transformers to the relay cabinet.

iv) Three conductor, #10 AWG extra hard usage wet location cord from the potential transformer cabinet to the relay cabinet.

v) SEL relay trigger circuit cable in accordance with Test Laboratory requirements.

vi) One 350 kcmil 15 kV concentric neutral cable from the sectionalizer cabinet to the test manhole. Label "Test-A in the manhole and at the sectionalizer. Terminations at the sectionalizer cabinet shall be 600 Amp dead-break elbow type. Terminations at the manhole shall be 600 Amp dead-break separable splice type. Provide and pre-fabricate (2) spare "Test-A" cables for contingency use at the test site.

vii) Perform insulation resistance test on all cable sections after fabrication and prior to test.

d. Provide faulted test cable sections:

i) Each faulted test cable section shall consist of (1) 2-piece of 350kcmil cable with an overall length of approximately 10-feet. Cable pieces shall be spliced together using faulted Raychem splice kits per Section entitled TEST SPLICES below. Connect to cable "Test-A" in the manhole using 600 Amp dead-break separable splice connectors. Bond splice concentric neutral grounds to faulted test cable and to the 4/0 ground within the manhole. Dead-end of cable shall be protected by heat shrinkable Raychem single conductor live end seal type HVES-1522D or equal. Prepare the cable and install the end caps per manufacturer's instructions.

ii) Number of faulted cable sections required is available from the Attachment 5 test table. This test table is prepared for performing the test in all current levels with all variables recommended by KSC.

iii) Twelve (12) test specimen cables shall be ready at site before the start of the test. Contractor shall consult and coordinate with the test lab and Government for selecting these specimens and the fuse wire size and configuration required for them. The remaining test specimen cables shall be prepared on site based on test results. Remaining test specimen cables shall be pre-fabricated to the maximum extent possible (including dead-break connector and end seal) without installing the conductor faulting the core and shield conductors; any exposed insulation shall be sealed until the splice is completed at the test laboratory. Contractor shall have men and material to complete a minimum of eight (8) splices a day during the test.

iv) Two test splice specimens shall be prepared without splice cover (tubes) to visually analyze the arc flash. The test current and the size of fault wire will be decided during the testing.

v) Contractor shall also provide test current calibration specimens as required per test lab requirement. Calibration specimen shall have an intentional short made with thick conductor that will withstand the test current during calibration.

vi) Identify all pre-fabricated test splices by initially labeling in accordance with the Attachment 5 Test Table.

vii) After the test, Contractor shall cut selected cables from both sides of the splice, pack it with splice tags to identify the test number, transport and deliver it to the Contracting Officer in KSC Florida for further X-raying and investigation.

viii) Certain tests may be repeated for conclusive results.

e. All cables and splices shall be secured inside the manhole on cable racks using heavy duty ty-wraps such that any movement of the test specimen during the test shall not damage the measuring instruments.

1.3.5. TEST SPLICES

a. Reference Attachments 3, 4, 5, 6, 7, 9, and 10.

b. Splices shall be made similar to the splices in the KSC power system using standard KSC splice kits. See the attached specification (Attachment 9) and splice product instruction sheets (Attachment 10).

c. Splice kits shall be Raychem HVS-1512-S-J for two tube splice and TE Energy HVS-C-1512-S-J-NASA for three tube splice.

d. An intentional fault shall be created by a thin copper fuse wire preinstalled inside the splice to create fault between the core conductor and shield. The thin fuse wire shall be inserted between the core conductor connector and the spring clamp that secures the concentric neutrals before completing the splices. This will establish a ground fault for the test between the conductor and shield. Two different fault connect methods will be tested:

i) "Parallel" fault wire installed from the core conductor splice location and routed parallel along the cable and connected to the concentric neutral.

ii) "Perpendicular" fault wire installed from the core conductor splice location and routed through the splice materials and connected to the concentric neutral. The probable best method of installation is drilling a hole and installing the fault wire between the core conductor and concentric neutral just prior to final tube installation.

e. The return path for the short circuit shall be arranged similar to the grounding conditions at KSC manhole. Connect concentric neutrals using a #4 AWG solid copper drain wire to the #4/0 test current return conductor; reference the splice photograph in Attachment 9.

f. The fuse wire shall be selected such that the wire will melt within the first half cycle leaving plasma for the arc to strike. The wire size for each fault shall be selected from the attached wire fusing chart as directed by the test laboratory. The fusing current for copper wires from #10AWG to #40AWG is calculated and a chart is prepared using Onderdonk formula for melting current of copper wire at 1083 deg. C and boiling current of copper at 2300 deg. C; reference Attachments 5, 6, and 7.

g. The Contractor shall provide adequate quantities of all fuse wire sizes and associated installation material to allow all splices completed at the test laboratory to be fabricated from any fuse wire size.

1.3.6. MANHOLE

a. Reference Attachment 4. Provide and install a manhole in the test facility as shown on the attached drawing. Manhole shall be 8ft x 8ft with 8ft head room, minimum.

b. Manhole shall be pre-cast octagonal, square, or rectangular type. Provide a personnel door or access hatch that opens inward, in one of the side walls for personnel entry during the testing process. Door arrangement shall prevent release of pressure through the door opening during cable fault testing.

c. Provide ventilation of manhole as required for confined space entries.

d. Duct openings shall be sealed after cable installation, prior to testing.

e. Install a #4/0 ground wire around the manhole and extend it to the sectionalizing cabinet and test generator connections.

f. Install cable racks and arms in the manhole to support the separable splices and the Raychem splices.

g. Install a switched 120-Volt power 150 – Watt incandescent work light in the manhole with full lamp guard. Provide extension cord assembly for power supply.

h. Provide and install easily removable supports for the lab supplied instruments inside the manhole in coordination with the Laboratory.

1.3.7. ACCESSORIES

a. Contractor shall provide and install the following accessories per test lab directions and requirements:

i) Two (2) Manikin(s) (constructed of fire-proof materials). One manikin shall be dressed head to toe in current NFPA 70E Category 2 PPE and the other in current NFPA 70E Category 0 PPE.

ii) Arc-flash PPEs for manikins. Provide two (2) sets of Category 2 PPE in accordance with the Attachment 8 Excerpts from KSC Power Manhole Entry Safety Requirements. Provide (2) sets of Category 0 PPE.

iii) Arc-flash blankets. Provide seven (7) unaltered 40KA rated blankets adequately sized to cover over a splice in accordance with the Attachment 8 Excerpts from KSC Power Manhole Entry Safety Requirements.

iv) Power extension cords for SEL relay, manhole light/blower, and tools. Portable generators and inverters if required convenience and accessory power is not available; coordinate requirements with the Test Laboratory.

v) 5kV DC insulation resistance tester with adjustable output.

vi) Micro-Ohmmeter utilizing 2-wire balanced test leads. Resistance of all faulted connections shall be measured and recorded prior to testing.

1.3.8. DEMONSTRATION INSTALLATION

a. Completely procure and install the entire test assembly at Contractor's premises or at a site selected by the Contractor. Installation in all aspects shall be as planned for the test laboratory site.

b. Government and the test lab shall inspect the site to ensure no modifications are required prior to disassembly and shipment to the test laboratory site. Provide 21-day notice to the Government prior to the inspection date.

c. Provide test voltage and current sources to demonstrate the SEL-751A relay is operable. Demonstrate data retrieval and file storage methodology.

d. Hold coordination meeting with the Test Laboratory. Review the test procedures/checklists and safety plans with the Government representative.

1.3.9. SUPPORT AT TEST LABORATORY SITE

a. Provide work crew at the test laboratory site for a minimum duration of five (5) test days, Monday through Friday. Unless otherwise directed by the testing laboratory or Government representative, Contractor personnel shall be on site 30-minutes prior to and 1-hour after the 8-hour testing period. Augment crews as required for initial set-up of equipment and removal of equipment. Test laboratory set-up and removal of equipment dates shall be per the test laboratory requirements including Saturday and Sunday as required. Rotate support personnel as required to meet any employee work week hour restrictions.

b. Ship all test equipment and materials to the test laboratory on a date acceptable to the test laboratory. All set-up shall be complete prior to the five (5) test days.

c. Comply with all laboratory safety procedures; provide a written test lab site specific safety plan for the work and brief all employees.

d. Transport and unload all materials and equipment at the site. Provide any crane and fork-lift services required to set the manhole and other equipment.

e. Set-up and connect equipment and cables; provide a checklist for the initial set-up and each subsequent test.

f. Perform Insulation resistance and micro-ohmmeter check on all power circuits as required prior to each test.

g. Remove faulted cables and install additional faulted cables for the various test sequences.

h. Provide manikin with PPE and arc-flash blankets as required for the various test sequences.

1.3.10. TEST METHODOLOGY

Tests will be performed to include the following prospective ground fault levels; testing is indicated by priority:

a. Reduced line to ground fault current at 800, equivalent of a "minimum sized" line to neutral resistor installed in KSC system. Recommended resistor size is 10 ohms (800A 10 sec).

b. Reduced line to ground fault current at 400A, equivalent of a "normally sized" line to neutral resistor installed in KSC system. Recommended resistor size is 20 ohms (400A 10 Sec).

c. At KSC maximum line to ground fault level of approximately 10,000 Amps (fault in a manhole near to the substation - without any neutral resistor).

d. Line to ground fault level at half of the maximum level (5000Amps – fault in a manhole away from the substation - no neutral resistor).

e. Line to ground fault level at one-quarter the maximum level (2500 Amps, fault in a manhole at the farthest end of long cable - no neutral resistor).

f. Fault duration shall be 6-cycle (1 cycle relay operating time and 5 cycles breaker operating time - 0.1 second arc duration) on the single phase.

g. Multiple tests at each fault level will be performed as shown on the attached test table. Contractor shall provide test splices and install them along with the instruments as directed by test lab team.

1.3.10.1. Fault inside a splice shall be created by deliberately shorting the test cable core conductor to the concentric neutral using a fuse wire Copper conductor melting current for desired time can be calculated using the Onderdonk formula for copper melting temperature at 1083 deg. C shown below. The fuse wire shall be selected such that the wire will melt within half cycle after applying the fault current. Contractor shall use test lab expertise also to determine the correct size of fuse wire for each test.

I.M. Onderdonk equation for Ifuse = $A\cdot\sqrt{\left[\frac{\log\frac{(Tm-Ta)}{(234+Ta)+1}}{t\cdot 33}\right]}$

Where:
A = Area of wire in circular mils
Tm = Melting temp of copper wire in deg. C
Ta = ambient temp in deg. C
`t = melting time in seconds
Ifuse = Fusing current in amps
Melting current and boiling current for various AWG copper wire are shown in the Attachments 6 & 7 for reference.

1.3.10.2 Tests performed and test methodology will be adjusted as required due to the results of previous tests performed.

1.4 TEST RESULTS

After testing is complete, provide all test results to Government in accordance with Attachment 1 Scope of Work for Manhole Arc-Flash Testing Laboratory Services.

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ATTACHMENT 1

SCOPE OF WORK FOR

Manhole Arc-Flash Testing

Laboratory Services

Project Control Number (PCN): 98954

Fiscal Year (FY) – 2013

DATE: March 25, 2013

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ATTACHMENT 1

MANHOLE ARC-FLASH TESTING

LABORATORY SERVICES

1. SCOPE

1.1. IMPERATIVE FORM

1.1.1. This Scope of Work (SOW) is written in imperative form and this imperative language is directed to the Testing laboratory, unless specifically noted otherwise. The main contractor of this project will be referred as the Contractor in this document. Laboratory services will be a subcontract to the main contractor.

1.2. DESCRIPTION

Provide electrical high power testing services to determine the arc flash impact on cable splices inside a manhole/ vault to mimic the ground fault occurrences in the 15kV power system. Develop and execute a testing plan and provide complete test results. All tests, equipment and test criteria shall conform to IEEE standard C37.20.7-2007 and IEEE standard 1584-2002. Testing shall occur at a Lab specializing in such high current power testing. Testing will have to be performed at various test current levels from 10kA to 400A at 8kV phase to ground. Test lab services are required for at least one week to complete the tests on all specimens at a minimum of six tests per day. The contractor will provide all support services required to conduct the tests.

1.2.1. TESTING OBJECTIVE

The primary objective of this testing is to determine, if such a condition exists, where the combination of reduced line to ground fault current level occurring on a splice within a manhole with a 6 cycle interrupting time significantly results in a reduced hazard to personnel working within a manhole or cable vault located at the Kennedy Space Center (KSC). If testing indicates a current level threshold significantly reduces risk, then KSC will pursue a project to install neutral resistors on its Substation transformers to limit fault current accordingly. A secondary objective is to determine, through testing, the existing hazard risk within manholes with the present ground fault current levels at various locations in the system and a 6-cycle interrupting time.

1.2.2. EQUIPMENT AND SERVICES FURNISHED BY OTHERS

1.2.2.1. Following equipment and services will be furnished by the main Contractor in coordination with the test lab requirements.

a. The Contractor will provide and install a manhole that is similar to the standard 15kV manholes used in KSC power system as shown on Attachment 4.

b. The cables and splices will be provided and installed by the Contractor according to the requirements of the test lab procedure. The Test Laboratory shall provide requirements of any calibration test specimens required to the Contractor.

c. The Contractor will install a Schweitzer Model 751A relay in the test voltage and current circuit to capture the oscillographic information for comparison with actual field readings obtained during cable faults. Test Laboratory shall provide a trigger for the relay to start taking the samples at the same time the fault is triggered. The Contractor will provide and install a laptop PC that will capture, store and analyze all test results including the SEL751A relay oscillographs.

d. The Contractor will furnish single phase 350kcmil cable with concentric neutral for the test equipment connection. Fault return path will be through the concentric neutral of supplying cable and an additional #4/0 cable to mimic the actual fault condition in the field.

e. Cables connecting to the laboratory test source will be provided with a connection mean as required by the test lab. The Test Laboratory shall provide the required connection means to the Contractor.

f. Connecting the cables to the test equipment and installing splices on the cable etc. will be performed by the Contractor. Concrete manhole including installation and preparations for personnel access, test cables, etc. will be provided by the Contractor.

g. Other auxiliary requirements like manikin, PPE for manikin, arc-flash blankets, confined space entry equipment, cable terminations, Instrument transformers for SEL relay etc. will be provided and installed in place by the Contractor.

h. Any auxiliary power requirements for the relays and test equipment shall be provided by the test laboratory.

1.3. STATEMENT OF WORK

1.3.1 TEST LAB

a. Fully coordinate with the Contractor during all phases of this project including pre- and post- test laboratory operations. Provide documentation of all test lab technical and safety requirements for performing work at the test laboratory facility. Participate in pre-planning meetings with the Contractor and Government prior to arrival on site and after arrival on site. Review testing methodology proposed and Contractor provided equipment to be employed and notify the Contractor of recommended or mandatory changes. Provide all submittal information in Attachment 2 Document Submittal Register required by the Contractor for submittal to NASA.

b. Develop and provide to the Contractor all required test laboratory specific submittal information. Participate in a coordination meeting with the Government representative and the Contractor during the Government's inspection of the Contractor's test assembly fabrication.

c. Provide all labor, tools, materials, equipment and supervision to perform the test and analyze the test results as identified in this scope of work. Provide adequate personnel such that data from each test can be secured while preparations for the following test proceed to the maximum extent possible to maximize the number of tests that can be performed.

d. Provide five (5) continuous lab testing days, Monday through Friday. Available laboratory testing time per day shall be 8-hours with additional time allocated for breaks and lunch.

e. Test lab shall have the resources and equipment to perform arc-flash tests as recommended by IEEE standard C37.20.7-2007 and IEEE standard 1584-2002. Test equipment shall be sized to inject and control current from 400A to 10000A at 8kV phase to ground on a 350kcmil cable splice as shown on the test table.

f. The fault duration shall be controlled to 100ms (6 cycles) or as desired by the client (up to 12 cycles).

g. Provide following instrumentation and meters that are required to measure and record the results of arc flash test. Fire proof instrumentation cables shall be used for these sensors and meters.

   i) High speed video including any lens filters.

   ii) Camera and photography service for still photos. Photograph the faulted cable sections, arc-flash blanket, and manikin before and after the test.

   iii) Seven (7) Calorimeters arranged as described in IEEE 1584 section 8.2.

   iv) Pressure level sensors and meters - Numbers and location as recommended by the Test Laboratory.

   v) Sound level sensors and meters - Numbers and location as recommended by the Test Laboratory.

   vi) Oscillographic recording of voltage, current, and power for the entire duration of fault.

h. All sensors and meters shall have the periodically calibrated certificates per NETA standard and shall be available at the time of test.

i. Locate the calorimeters per IEEE standard 1584 section 8.2.

1.3.2. TEST CRITERIA

1.3.2.1. All tests shall include the following electrical characteristics. Based on initial actual test results, criteria will be modified as necessary during the testing period.

a. Ground fault at a cable splice from the core conductor to its concentric neutral on a 13.8 kV 3-phase solidly grounded system; approximately 8000 V line-to ground. Fault shall be created by a thin fuse copper wire preinstalled inside the splice to create fault between the core conductor and shield. The fuse wire shall be selected such that the wire will melt within the first half cycle leaving plasma for the arc to strike; therefore, test samples for each test current value will have its own fuse wire size. A fuse wire melting chart is prepared using Onderdonk melting current formula for copper wires at 1083 deg. C. Current at boiling temperature of 2300 deg. C also is calculated and attached to this scope for reference. Wire with ASTM Class K stranding has shown consistent results regarding arc duration. Test lab shall use their engineering expertise to determine the correct fuse wire size for each test and advise the Contractor before making the splices.

b. Fault duration shall be 6-cycle (1 cycle relay operating time and 5 cycles breaker operating time - 0.1 second arc duration) on the single phase.

c. The 15kV cables for test splices will be 350 kcmil and #4/0 AWG EPR cables with 1/3 concentric neutral per KSC specifications. Ground fault return will be through the concentric neutral of the cable and an additional #4/0 bare copper ground. All conductors in the return path shall be connected to the test source neutral and grounded.

d. Phase current and voltage shall be measured digitally and recorded for the period of test using a digital oscilloscope to measure and compute the arc power and arc energy. Use RMS values to compute arc power. Calculate the arc energy by integrating arc power over the arc duration. Use the menu driven compute functions of the oscilloscope to compute these values.

e. Splice shall be typical KSC EPR to EPR cable in-line kit type and shall satisfy NASA requirements per specification 26 05 13.00 98 and attached drawings.

f. The prospective short circuit current shall be calibrated using the measured (or calculated) impedance of the test cable along with the return path. If test voltage is adjusted to calibrate the arc current, voltage shall not be reduced to less than 60% of the rated voltage.

g. The arc shall not extinguish before the set arc duration due to the reduced voltage applied.

h. Test shall be considered valid in a premature arc extinguishing situation only if the test voltage was set to the maximum, the peak current requirement is met per IEEE Standard C37.20.7 section 5.2.2.

i. For the maximum fault current test, the peak current provided by the DC component at the instant of closing shall be 2.6 times the arcing current. For this, X/R ratio of the test source shall not be less than 15 which will give an asymmetrical to symmetrical RMS current ratio of 1.6. Fault initiation switch shall be closed at voltage zero crossing instant to provide the DC offset.

j. For all other tests from 5000A to 400A asymmetry is not required. RMS value of the fault current shall be as indicated in section 1.3.2.2.

k. The short circuit generator, the transformer with taps for voltage adjustment and the series reactors and resistors for current adjustment shall be sized for the maximum test MVA.

l. AC component of the test current shall remain constant. All voltage and current tolerances shall be set to +5% to -0% per IEEE Standard C37.20.7 section 5.2.3.

m. IEEE standard C37.20.7 section 5.2.5 requires the test current and voltage for an arcing duration of more than 50ms shall be set to +/-10% of the rated frequency and the frequency of the waveform shall not deviate more than 8% during the test.

1.3.2.2 Tests shall be performed to include the following prospective ground fault levels; testing is indicated by priority:

a. Reduced line to ground fault current at 800, equivalent of a "minimum sized" line to neutral resistor installed in KSC system. Recommended resistor size is 10 ohms (800A 10 sec).

b. Reduced line to ground fault current at 400A, equivalent of a "normally sized" line to neutral resistor installed in KSC system. Recommended resistor size is 20 ohms (400A 10 Sec)

c. At KSC maximum line to ground fault level of approximately 10,000 Amps (fault in a manhole near to the substation - without any neutral resistor).

d. Line to ground fault level at half of the maximum level (5000 Amps- fault in a manhole away from the substation - no neutral resistor).

e. Line to ground fault level at one-quarter the maximum level (2500 Amps, fault in a manhole at the farthest end of long cable - no neutral resistor).

1.3.2.3. Multiple tests at each fault level will be performed to include but not necessarily be limited to the following variables:

a. No arc-flash blanket with and without manikin.

b. Arc-flash blanket just draped over splices with and without manikin.

c. Manikin with varying levels of PPE.

d. Fault directed at various directions with manikin in the manhole.

1.3.3. TEST METHODOLOGY

1.3.3.1. General test methodology shall be as follows:

a. The short circuit generator shall be connected to a short circuit transformer with several tap combinations in primary and secondary windings so that the test voltage can be adjusted to the desired value and provide the test current to the sample.

b. Calibration samples as required by the Testing Laboratory will be used to pre-calibrate various test currents.

c. This calibration shall be done using a variable load (Z) at the test voltage connected in series with the test calibration sample. Value of Z shall be calculated and adjusted with the test sample impedance at constant voltage.

d. After the calibration the calibration sample will be removed from the circuit and testing station will be connected to the test sample.

e. All meters and instrumentation shall be connected in place and shall be ready to record the readings.

f. The short circuit initiation breaker shall be pre-set to open the circuit after the designated time of 100ms including the breaker opening time.

g. Install the blankets, manikins with or without PPE etc. as required by the test sequence.

h. Check all safety features, secure the test area and ascertain that there are no safety issues for personnel.

i. Switch on the test circuit breaker. Pre-set fault current will flow through the circuit for 100ms and the circuit breaker will automatically open.

j. Save and file data from the meters and sensors.

k. Repeat the test with new sample for the next fault current

1.3.4. TEST RESULTS

1.3.4.1. Test results shall be recorded and submitted to Government in an excel format consisting of the following information as a minimum. Each test shall be identified by a unique test number and the corresponding test specimen shall be tagged with the same number. The test results not included in the excel spread sheet, such as high speed video, still photographs, current/voltage/power oscillographic prints, SEL relay data, and any other test values shall also be identified by the test number so that all

results for a particular test can be related easily.

1.3.4.2. As a minimum the following information shall be included in the test result spread sheet:

a. Test number or ID

b. Applied Voltage

c. RMS value of Injected Current

d. Peak value of Injected current

e. Size of fuse wire used for splice fault

f. Manikin (yes/no)

g. PPE (PPE2/PPE0/No PPE)

h. Arc flash Blanket (yes/no)

i. Set time for fault injection (100msec)

j. Time of fault isolation (if isolation happens before 100msec)

k. Pressure meter reading

l. Sound meter reading

m. Calorimeter readings (1 to 7)

n. Average calorimeter reading

o. Calculated calories (per IEEE 1584)

p. Calculated arc power in MW

q. Remarks (shall indicate damage to manikins, effect on PPEs, and any visual results)

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ATTACHMENT 2 – DOCUMENT SUBMITTAL REGISTER

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ATTACHMENT 2 - DOCUMENT SUBMITTAL REGISTER.

PROJECT DESCRIPTION: MANHOLE ARC-FLASH TESTING.
PCN NUMBER: 98954 .

ITEM	DOCUMENT/DATA	COPIES REQ'D WITH QUOTE	QUANTITIES REQUIRED					
			FOR APPROVAL			FINAL		
			PRINT	EC	DATE REQ'D	PRINT	EC	DATE REQ'D
	MANHOLE ARCFLASH TESTING							
1	**Detailed project schedule with the following elements, milestones, and durations defined:** **a. Coordination with test laboratory** **b. Each set of submittals** **c. Material procurement** **d. Test assembly fabrication** **e. Government inspection of test assembly and TEST LABORATORY coordination meeting** **f. Travel time to test laboratory** **g. Pre-test coordination and safety meeting at the test laboratory** **h. Set-up time at test laboratory** **i. Laboratory test time** **j. Disassembly time at test laboratory** **k. Final deliverables**		2	1	A	2	1	G
2	**TEST LABORATORY operational and safety requirements.**					2	1	A
3	**Detailed Bill of Materials and Equipment including description, manufacturer, part number, and quantity for:** **a. Support contractor supplied items** **b. TEST LABORATORY supplied items**		2	1	B	2	1	C
4	**Data sheets of material equipment and instruments:** **a. Medium voltage cable** **b. Low voltage cable** **b. Medium voltage cable splice kits** **c. Medium voltage connectors** **d. Sectionalizer cabinet** **e. Potential transformer** **f. Current transformer** **g. Protective relay and auxiliary components (computer, software, cables, etc.)** **h. Manhole and modification materials (arms, racks, holders, lighting, access, etc.)** **i. Manikin** **j. Arc-flash personnel protective equipment (PPE)** **k. Arc-flash blankets** **i. TEST LABORATORY supplied instrumentation/video**		2	1	B	2	1	C

ITEM	DOCUMENT/DATA	COPIES REQ'D WITH QUOTE	QUANTITIES REQUIRED FOR APPROVAL			FINAL		
			PRINT	EC	DATE REQ'D	PRINT	EC	DATE REQ'D
5	Shop drawings showing test assembly plan views, fabrication details, and configuration. All drawings shall be based on the TEST LABORATORY site and shall be coordinated with and approved by the TEST LABORATORY: a. Manhole including modifications required for personnel access, power cable routing/sealing/securing, and provisons for TEST LABORATORY instrumentation/equipment. b. Sectionalizer, PT, and relay cabinets c. Test power cabling d. Schweitzer relay cabling e. TEST LABORATORY instrumentation and connecting cabling		2	1	C	2	1	D
6	Instructions, testing procedures, checklists, and forms for recording results and identifying test data prepared in coordination with the TEST LABORATORY.		2	1	D	2	1	G AND E
7	Detail and schedule of TEST LABORATORY supplied personnel, equipment and materials at lab site		2	1	D	2	1	G AND E
8	Detail and schedule of Contractor's support personnel, equipment, and materials at lab site		2	1	D	2	1	G AND E
9	Final Safety procedures including: a. TEST LABORATORY safety procedures for Contractor support personnel. b. TEST LABORATORY safety procedures for Government witnesses. c. Contractor's site specific safety plan including Job Hazard Analysis.		2	1	D	2	1	G AND E
10	Test result submittal including all forms and all recorded data for each test performed.		2	1	F	2	1	G
11	Return of all test materials to KSC					2	1	F

NOTE: 1. ALL DOCUMENTS AND DATA SUBMITTALS MUST BE REFERENCED TO THE INQUIRY OR PCN NO., AND ITEM DESIGNATOR.
2. PRINT – A OR C SIZE SHEETS WITH ELECTRONIC FILES ON A CD
3. EC- ELECTRONIC COPY BY E-MAIL

DATE REQUIREMENT KEY (CALENDAR WEEKS)
A - 4 WEEKS AFTER CONTRACT AWARD
B - 2 WEEKS PRIOR TO MATERIAL PROCUREMENT
C - 2 WEEKS PRIOR TO FABRICATION OF TEST ASSEMBLY
D - 2 WEEKS PRIOR TO GOVERNMENT INSEPCTION OF TEST ASSEMBLY
E - 2 WEEKS PRIOR TO TESTING AT LABORATORY
F – 2 WEEKS AFTER TESTING IS COMPLETED
G - AFTER APPROVAL AND INCORPORATION OF COMMENTS

ATTACHMENT 3 – TEST CIRCUIT DIAGRAM SKETCH SKE-001

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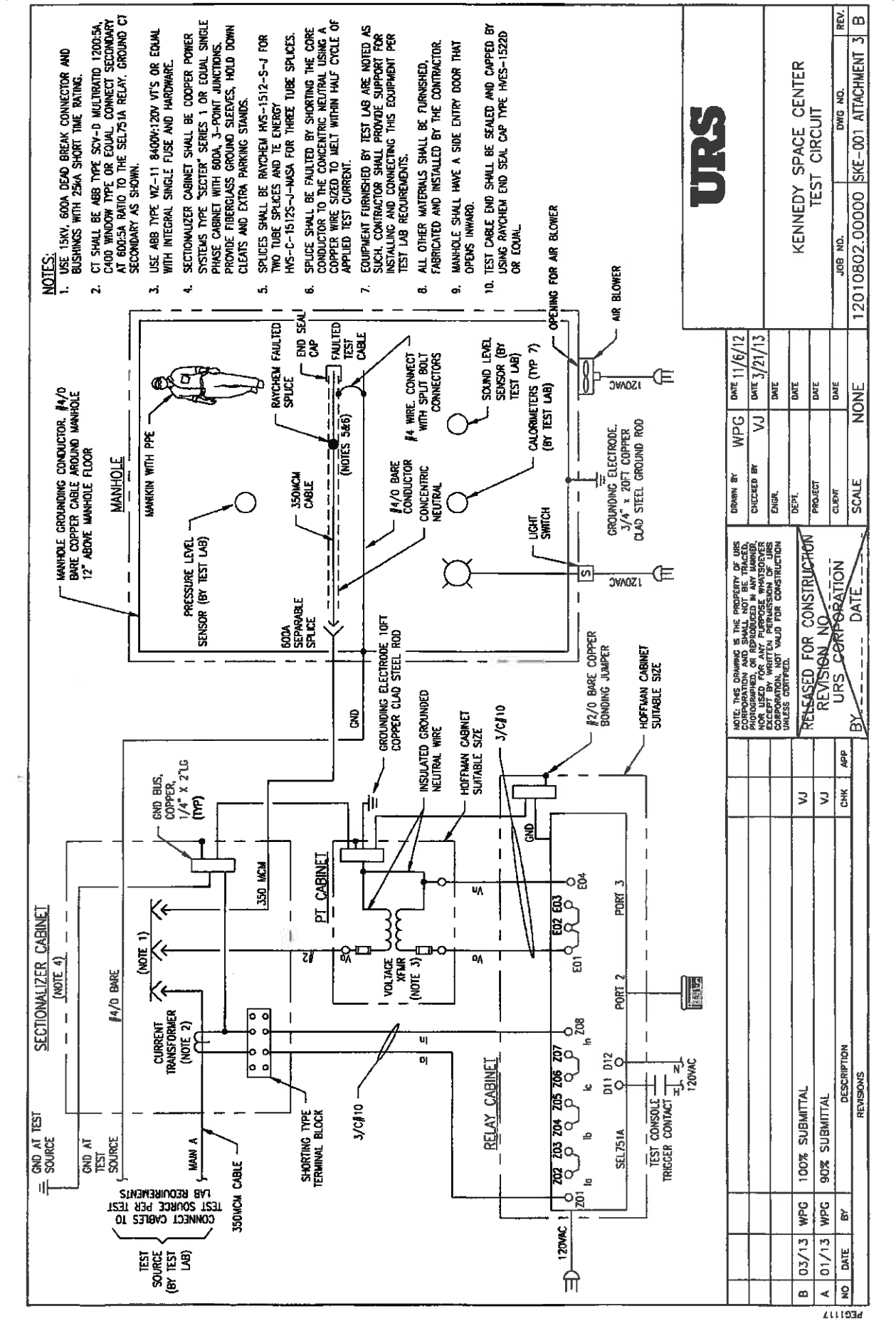
NOTES:
1. USE 15KV, 600A DEAD BREAK CONNECTOR AND BUSHINGS WITH 25kA SHORT TIME RATING.
2. CT SHALL BE ABB TYPE SCV-D MULTIRATIO 1200:5A, C400 WINDOW TYPE OR EQUAL. CONNECT SECONDARY AT 600:5A RATIO TO THE SEL751A RELAY. GROUND CT SECONDARY AS SHOWN.
3. USE ABB TYPE VIZ-11 8400V:120V VT'S OR EQUAL WITH INTEGRAL SINGLE FUSE AND HARDWARE.
4. SECTIONALIZER CABINET SHALL BE COOPER POWER SYSTEMS TYPE "SECTER" SERIES 1 OR EQUAL SINGLE PHASE CABINET WITH 600A, 3-POINT JUNCTIONS. PROVIDE FIBERGLASS GROUND SLEEVES, HOLD DOWN CLEATS AND EXTRA PARKING STANDS.
5. SPLICES SHALL BE RAYCHEM HVS-1512-S-J FOR TWO TUBE SPLICES AND TE ENERGY HVS-C-1512S-J-NASA FOR THREE TUBE SPLICES.
6. SPLICE SHALL BE FAULTED BY SHORTING THE CORE CONDUCTOR TO THE CONCENTRIC NEUTRAL USING A COPPER WIRE SIZED TO MELT WITHIN HALF CYCLE OF APPLIED TEST CURRENT.
7. EQUIPMENT FURNISHED BY TEST LAB ARE NOTED AS SUCH. CONTRACTOR SHALL PROVIDE SUPPORT FOR INSTALLING AND CONNECTING THIS EQUIPMENT PER TEST LAB REQUIREMENTS.
8. ALL OTHER MATERIALS SHALL BE FURNISHED, FABRICATED AND INSTALLED BY THE CONTRACTOR.
9. MANHOLE SHALL HAVE A SIDE ENTRY DOOR THAT OPENS INWARD.
10. TEST CABLE END SHALL BE SEALED AND CAPPED BY USING RAYCHEM END SEAL CAP TYPE HVES-1522D OR EQUAL.
MANHOLE GROUNDING CONDUCTOR. #4/0 BARE COPPER CABLE AROUND MANHOLE 12" ABOVE MANHOLE FLOOR
MANHOLE
MANIKIN WITH PPE
PRESSURE LEVEL SENSOR (BY TEST LAB)
350MCM CABLE
RAYCHEM SPLICE
END SEAL CAP
FAULTED TEST CABLE
(NOTES 5&6)
#4/0 BARE CONCENTRIC NEUTRAL
#4 WIRE CONNECT WITH SPLIT BOLT CONNECTORS
SOUND LEVEL SENSOR (BY TEST LAB)
CALORIMETERS (TYP 7) (BY TEST LAB)
OPENING FOR AIR BLOWER
AIR BLOWER
120VAC
LIGHT SWITCH
GROUNDING ELECTRODE. 3/4" x 20FT COPPER CLAD STEEL GROUND ROD
600A SEPARABLE SPLICE
GROUNDING ELECTRODE 10FT COPPER CLAD STEEL ROD
GND
#2/0 BARE COPPER BONDING JUMPER
HOFFMAN CABINET SUITABLE SIZE
GND BUS, COPPER, 1/4" X 2"LG (TYP)
INSULATED GROUNDED NEUTRAL WIRE
3/C#10
SECTIONALIZER CABINET
(NOTE 4)
#4/0 BARE
(NOTE 1)
CURRENT TRANSFORMER (NOTE 2)
350 MCM
PT CABINET
VOLTAGE XFMR (NOTE 3)
PORT 2
PORT 3
RELAY CABINET
SEL751A
SHORTING TYPE TERMINAL BLOCK
TEST CONSOLE TRIGGER CONTACT
120VAC
GND AT TEST SOURCE
MAIN A
350MCM CABLE
CONNECT CABLES TO TEST SOURCE PER TEST LAB REQUIREMENTS
TEST SOURCE (BY TEST LAB)
B 03/13 WPG 100% SUBMITTAL VJ
A 01/13 WPG 90% SUBMITTAL VJ
NO DATE BY DESCRIPTION CHK APP
REVISIONS
NOTE: THIS DRAWING IS THE PROPERTY OF URS CORPORATION AND SHALL NOT BE TRACED, PHOTOGRAPHED, OR REPRODUCED IN ANY MANNER, NOR LOANED FOR ANY PURPOSE WHATSOEVER EXCEPT BY WRITTEN PERMISSION OF URS CORPORATION. NOT VALID FOR CONSTRUCTION UNLESS CERTIFIED.
RELEASED FOR CONSTRUCTION
REVISION NO. ____
URS CORPORATION
BY _____ DATE _____
DRAWN BY WPG DATE 11/6/12
CHECKED BY VJ DATE 3/21/13
ENGR. DATE
DEPT. DATE
PROJECT DATE
CLIENT DATE
SCALE NONE
URS
KENNEDY SPACE CENTER
TEST CIRCUIT
JOB NO. 12010802.00000
DWG NO. SKE-001 ATTACHMENT 3
REV. B

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ATTACHMENT 4 – MANHOLE DETAIL SKETCH SKE-002

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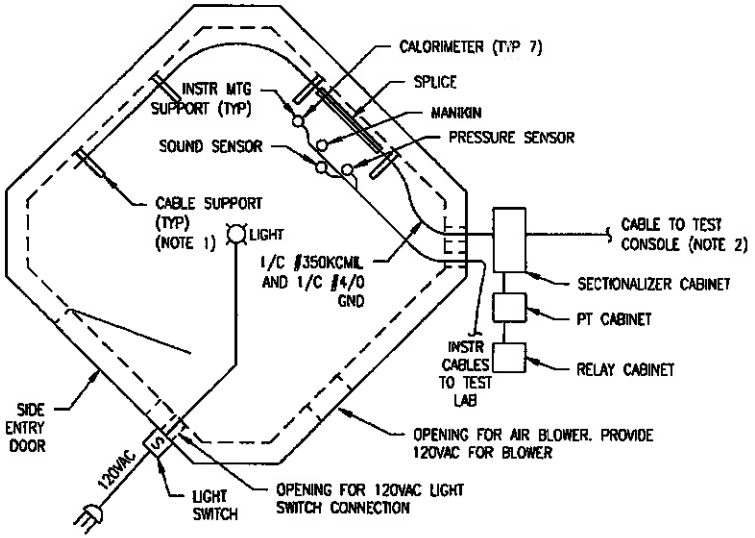
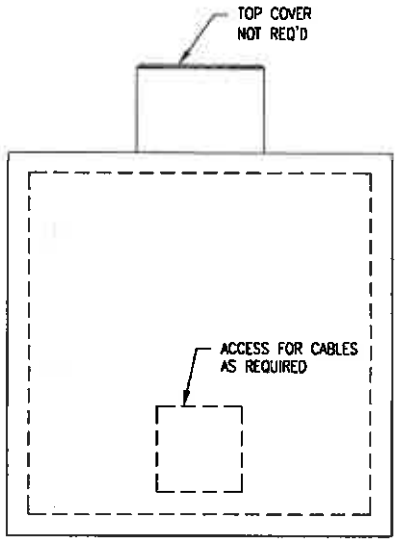
NOTES:
1. PROVIDE STANDARD CABLE RACK, ARMS AND HOLDERS IN THE MANHOLE TO SUPPORT AND SECURE CABLE AND SPLICE.
2. LAY AND SECURE THE CABLES TO TEST LAB ACCORDING TO THE LAB REQUIREMENTS.



PLAN
3/8"=1'-0"



SECTION
3/8"=1'-0"

NO	DATE	BY	DESCRIPTION	CHK	APP
B	03/13	WPG	100% SUBMITTAL	VJ	
A	01/13	WPG	90% SUBMITTAL	VJ	

REVISIONS

PEG1117

RELEASED FOR CONSTRUCTION
REVISION NO.
URS CORPORATION
BY DATE

DRAWN BY	WPG	DATE 10/17/12
CHECKED BY		DATE
ENGR.		DATE
DEPT.		DATE
PROJECT		DATE
CLIENT		DATE
SCALE	AS NOTED	

URS

KENNEDY SPACE CENTER
MANHOLE DETAILS

JOB NO.	DWG NO.	REV.
12010802.00000	SKE-002 ATTACHMENT 4	B

WAYNE_GREGOIRE P:\NASA-KSC\12010802\ELEC\DWG\ATTACHMENT 4.DWG PLOTTED: 03/27/2013 09:24

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ATTACHMENT 5 – TEST TABLE

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Attachment 5 - Test Table

Test No.	Test Current	350 MCM Cable	4/0 Cable	2 Tube Splice Kit	3 Tube Splice Kit	Fabricate Fully In Advance	Manikin with PPE 2	Manikin with PPE 0	Arc-flash Blanket
1	800A	X		X		X	X		
2	800A	X		X				X	
3	800A	X		X			X		
4	800A	X		X				X	X
5	800A	X		X			X		
5a Note 2	800A	X		X		X		X	
6	800A		X	X		X	X		
7	800A		X	X				X	
8	800A		X	X			X		X
9	800A		X	X				X	
10	800A		X	X			X		
10a Note 1	800A	X			X				
10b Note 1	800A		X		X				
11	400A	X		X		X	X		
12	400A	X		X				X	
13	400A	X		X			X		
14	400A	X		X				X	X
15	400A	X		X			X		
16	400A		X	X		X		X	
17	400A		X	X			X		
18	400A		X	X				X	X
19	400A		X	X			X		
20	400A		X	X				X	
20a Note 1	400A	X			X				
20b Note 1	400A		X		X				
21	10kA	X		X		X	X		
22	10kA	X		X				X	X
22a Note 2	10kA	X		X		X	X		
23	10kA		X	X		X		X	
24	10kA		X	X			X		
24a Note 1	10kA	X			X				
24b Note 1	10kA		X		X				
25	5kA	X		X		X	X		
26	5kA	X		X				X	X
27	5kA		X	X		X	X		
28	5kA		X	X				X	
28a Note 1	5kA	X			X				
28b Note 1	5kA		X		X				
29	2.5kA	X		X		X	X		
30	2.5kA	X		X				X	X
31	2.5kA		X	X		X	X		
32	2.5kA		X	X				X	
32a Note 1	2.5kA	X			X				
32b Note 1	2.5kA		X		X				

Notes:

1. Provide materials to fabricate for substitute test if required.
2. Fabricate sample without insulation installed for substitute test.

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ATTACHMENT 6 – WIRE FUSING CURRENT CALCULATION

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ATTACHMENT 6 - WIRE FUSING CURRENT CALCULATION

at Copper melting temperature = 1083 deg C.

SR.No.	Wire gage	Wire diameter in inch	Area in cmil	Fusing Current in Amperes at 1083 deg C			
				1/2 Cycle= 0.0083sec	1 Cycle= 0.0167 sec	1 1/2 cycle= 0.0250 sec	2 Cycle= 0.0333 sec
1	10	0.1019	10383.61	16674.11	11755.02	9607.5288	8324.527
2	12	0.08081	6530.256	10486.35	7392.738	6042.1784	5235.298
3	14	0.06408	4106.246	6593.853	4893.371	3799.3415	3291.973
4	16	0.0508	2580.64	4144.019	2921.477	2387.7604	2068.896
5	18	0.0403	1624.09	2607.981	1838.591	1502.7039	1302.031
6	20	0.03196	1021.442	1640.242	1156.348	945.09805	818.8885
7	22	0.02535	642.6225	1031.93	727.4967	594.59227	515.1897
8	24	0.0201	404.01	648.7635	457.3695	373.8139	323.8943
9	26	0.01594	254.0836	408.0101	287.6416	235.09314	203.6985
10	28	0.01264	159.7696	256.5597	180.8711	147.82826	128.0871
11	30	0.0103	106.09	170.3604	120.1018	98.16073	85.05222
12	32	0.00796	63.3616	101.7467	71.73007	58.625892	50.79692
13	34	0.0063	39.69	63.73462	44.93205	36.723531	31.81942
14	36	0.005	25	40.14526	28.30187	23.131476	20.04247
15	38	0.003965	15.72123	25.24531	17.7976	14.546205	12.60369
16	40	0.003146	9.897316	15.89321	11.2045	9.1575809	7.934666

Note: 1 Fusing current-time characteristics of copper conductor is determined by I.M.onderdonk's formula for copper conductor melting per Fink &Beaty's Standard Handbook for Electrical Engineers Section 4.

2 RMS value of the current that will melt the AWG size of copper wire is calculated.

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ATTACHMENT 7 – WIRE FUSING CURRENT CALCULATION

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ATTACHMENT 7 - WIRE FUSING CURRENT CALCULATION

at Copper boiling temperature = 2300 deg C.

SR.No.	Wire gage	Wire diameter in inch	Area in cmil	Boiling Current in Amperes at 2300 deg C			
				1/2 Cycle= 0.0083sec	1 Cycle= 0.0167 sec	1 1/2 cycle= 0.0250 sec	2 Cycle= 0.0333 sec
1	10	0.1019	10383.61	19746.09	13920.73	11377.586	9858.209
2	12	0.08081	6530.256	12418.32	8754.75	7155.3681	6199.831
3	14	0.06408	4106.246	7808.682	5505.015	4499.3189	3898.474
4	16	0.0508	2580.64	4907.498	3459.72	2827.673	2450.062
5	18	0.0403	1624.09	3088.466	2177.327	1779.5568	1541.913
6	20	0.03196	1021.442	1942.434	1369.39	1119.2196	969.7576
7	22	0.02535	642.6225	1222.049	861.5281	704.13786	610.1064
8	24	0.0201	404.01	768.2894	541.6337	442.68406	383.5675
9	26	0.01594	254.0836	483.1805	340.6357	278.40588	241.2272
10	28	0.01264	159.7696	303.8274	214.1942	175.06362	151.6854
11	30	0.0103	106.09	201.747	142.2289	116.24552	100.7219
12	32	0.00796	63.3616	120.4922	84.94536	69.42692	60.15556
13	34	0.0063	39.69	75.47686	53.21017	43.489345	37.68172
14	36	0.005	25	47.54148	33.51611	27.393137	23.73502
15	38	0.003965	15.72123	29.89641	21.07657	17.226147	14.92575
16	40	0.003146	9.897316	18.82132	13.26878	10.844741	9.396521

Note: 1 Fusing current-time characteristics of copper conductor is determined by I.M.onderdonk's formula for copper conductor melting per Fink &Beaty's Standard Handbook for Electrical Engineers Section 4.

2 RMS value of the current that will melt the AWG size of copper wire is calculated.

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ATTACHMENT 8 – EXCERPTS FROM KSC POWER MANHOLE ENTRY SAFETY REQUIREMENTS

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ATTACHMENT 8

EXCERPTS FROM KSC POWER MANHOLE ENTRY SAFETY REQUIREMENTS

2.0 PROTECTIVE CLOTHING AND PERSONAL PROTECTIVE EQUIPMENT (PPE)

2.1 NFPA 70E Category 2 PPE is the minimum permitted for entering manholes/vaults with energized cables; exceptions:

2.1.1 Hearing protection.

2.1.2 Face and head protection shall include a balaclava with eye-slit opening only, appropriate eye protection, and hard hat.

2.1.2.1 Face and head protection shall not be removed while within a manhole/vault with energized cables.

2.1.3 PPE shall be bloused tightly; no un-tucked shirts, collars and sleeves tight; use of ankle high boots, etc.

3.0 MANHOLE ENTRY PLAN FOR ELECTRICAL WORK WITH ENERGIZED FEEDERS:

3.1 PPE shall be in accordance with Section 2.0.

3.2 Arc Suppression blanket (40KA rated) installation is required between the workers and any energized cable splice within five (5) feet of the authorized workers for tasks including but not limited to cable splicing, pulling eye attachment, jamb skid set-up.

3.2.1 Draping of blankets over the splices is acceptable as a minimum.

3.2.2 Splices shall not be moved to install blankets.

3.2.3 Blanket installations involving modification to or attachment to the manhole structure shall be reviewed prior to installation to insure they do not introduce additional hazards (such as tripping) or potentially compromise the manhole structure.

Note: Manufacturer's generally recommend and testing has shown that installing blankets in "wall" or "J" configurations with the blanket positioned between the worker and the energized splices is most effective.

3.3 Once the arc suppression blanket(s) is(are) installed work can be performed as follows:

3.3.1 The worker shall maintain his/her torso at a minimum of 18 inches away from the nearest energized cable and/or splice.

3.3.2 Gloves and arc-flash face shield (if used) can be removed only for those tasks that cannot be done with this PPE on.

NOTE: The balaclava and eye protection must be left on at all times.

3.3.2.1 Gloves shall be worn to the maximum extent practical.

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ATTACHMENT 9 – KSC STANDARD SPECIFICATION FOR MEDIUM VOLTAGE CABLE AND SPLICE PHOTOGRAPH

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KSC STANDARD SPECIFICATION FOR MEDIUM VOLTAGE CABLE USED FOR PCN 98860 (REVITALIZE MEDIUM VOLTAGE ELECTRICAL DISTRIBUTION SYSTEM)IS USED IN THIS PACKAGE.
SPECIFICATION WILL BE UPDATED PER KSC COMMENTS IN THE 90% SUBMITTAL
OTHER DIV. 1 SPECS AND COMMON ELECTRICAL SPECS WILL BE INCLUDED IN THE 90% SUBMITTAL.

SECTION 26 05 13.00 98

MEDIUM-VOLTAGE CABLE
11/11

PART 1 GENERAL

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-94-649	(2004) Standard for Concentric Neutral Cables Rated 5 Through 46 KV

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE 400.2	(2004) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE 404	(2006) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE C62.11	(2005; Amd 1 2008) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
NETA MAINT	(2011) Standard for Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA WC 74/ICEA S-93-639	(2006) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; Errata 2 2012) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Aug 2011) Medium-Voltage Power Cables

1.2 DEFINITIONS

Medium voltage power cables means all cables rated above 601 to 35,000 volts.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

15 kV Concentric Neutral Cable; G

Cable Tags; G

Fireproof Tape; G

Splices (including splice grounding and list of recommended tools for splicing operations); G

Terminations; G

Cable end seals; G

SD-06 Test Reports (Not required)

SD-07 Certificates

Factory-Conducted Tests on Each Shipping Length (Reel) of Cable; G

Splicer/Terminator Certifications; G

List of Splices/Terminations provided by Splicer/Terminator; G

Conductor Resistance; G

High-Voltage; G

SD-08 Manufacturer's Instructions

Single Conductor 15 kV Shielded Cable; G

Terminations; G

Splices (including splice grounding); G

Cable end seals; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Verify personnel performing Medium Voltage (MV) splicing/terminations have 5 years minimum experience in cable splicing/terminations of the type used in this project. In addition, submit splicer/terminator certifications issued by the cable splice and termination manufacturer who has examined and tested a test splice/termination of each type required by this contract for each cable splicer/terminator. Ensure the certification identifies which splices/terminations it applies to. In addition require each individual, certified or not certified, with the required 5 years medium voltage splicing/terminating who is to perform cable splicing/terminating, to perform a minimum of one splice/termination of each type in the presence of the manufacturers' representative and the Government's representative. Contractor shall supply all materials, tools, and manufacturer's services required for the demonstration splices and tape type terminations. Submit each splice/termination performed by individuals without a manufacturer's certification to the manufacturer for testing and subsequent certification. Proof of certification will be verified by the NASA Contracting Officer's Technical Representative prior to installation of any splices/terminations. Certification is not required for load break elbows and dead break connectors.

Once a splice/termination has been started by a splicer/terminator, ensure the same splicer/terminator completes that particular splice/termination, and that each splice/termination is started and completed in one continuous work period. The Contractor shall maintain and submit a list of splices/terminations installed by splicer/terminator. The list shall include the following for each splice/termination completed:

- Name of splicer/terminator.

- Company name.
- Date splice/termination was performed.
- Test specimen number.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Shipping

Ship the cable and splices to the test facility in such a manner that the cable, splices and terminations are protected from mechanical injury. Hermetically seal every cable end of each length using heat-shrinkable molded cable end seal caps to exclude moisture and securely attached to the reel and shown on the drawings.

Ensure the minimum diameter of the reel drum is 14 times the overall diameter of the cable. For reels less than 60 inches in diameter, provide arbor holes sized for 2-1/2 inches spindles; for those greater than 60 inches in diameter, provide arbor holes sized for 3 inch spindles. Ensure reel sizes accommodate reel lengths specified in the purchase order, and that each reel contains only one length of cable cut to order.

Provide each reel with an arrow and appropriate wording, stenciled in plain view on each side, indicating proper rotation of reels. Plainly mark each reel on each side, and attach a tag to the cable end inside the lagging, stating the following information:

a. Purchaser's order number

b. Complete description of cable including manufacturer, cable size, voltage rating, percent insulation rating, insulating material, conductor size(s), year of manufacture

c. Actual shipping cable (reel) length

d. Reel number (e.g. 2 of 10)

e. Gross weight (i.e. with reel) and net weight (i.e. cable only)

Ship reels in a vertical position, sufficiently blocked in the bed of shipping vehicle to preclude movement.

Inform government after the cables are received from the manufacturer. Government may verify the materials before construction.

PART 2 PRODUCTS

2.1 CONDUCTORS

2.1.1 Material

Provide annealed copper core (phase) conductor material in accordance with ASTM B8.

2.1.2 Stranding

Provide Class B stranded conductors.

2.2 CABLE IDENTIFICATION

Provide cables with printing on the outer jacket showing the cable type, name of the manufacturer, the year in which the cable was manufactured, sequential cable reel length markings and a unique number for identification purposes. Closely group the information on the tape at 6 foot maximum intervals to permit complete identification.

2.3 15 KV CONCENTRIC NEUTRAL CABLE

2.3.1 General; 15 kV Cable

Provide single conductor 15 kV shielded cable assemblies consisting of:

a. Conductor core described above, an extruded semiconductor shield over the conductors

b. 220 mils of ethylene-propylene-rubber (EPR) insulation

c. An extruded semiconductor insulation shield, a concentric neutral

d. A polyethylene (PE) jacket.

Ensure cable is rated for minimum 194 degrees F continuous conductor temperature and 266 degrees F emergency overload.

Provide single-conductor, ethylene-propylene-insulated, polyethylene-jacketed, shielded cable conforming to ICEA S-94-649 and AEIC CS8.

2.3.2 15 kV Cable Conductor Shielding

Provide conductors with a stress control layer consisting of extruded material applied between the conductor and the insulation to form a conductor shield (strand screen). Ensure material has proven long-term chemical compatibility with both the conductor and overlying insulation materials, and that the stress control layer meets the electrical and physical requirements of ICEA S-94-649.

2.3.3 Insulation; 15 kV Cable

Provide ozone resistant insulation material, of extruded thermosetting ethylene-propylene based polymer, capable of withstanding the continuous and emergency overload temperature ratings of the conductor.

2.3.4 Non-metallic Insulation Shield; 15 kV Cable (NOT USED)

2.3.5 Concentric Neutral Shield; 15 kV Cable

Provide copper wires helically applied over the insulation shield, where the minimum total cross sectional area (of the shield wires) is 1/3 of the core conductor for 350 kcmil cable. Minimum size of an individual shield wire is No. 14 AWG.

2.3.6 Jacket; 15 kV Cable

Provide polyethylene jacketed cable (PE) extruded over the concentric neutral to a minimum thickness of 80 mils.

2.4 INSULATED MEDIUM VOLTAGE CONNECTORS

Provide insulated medium voltage connectors for new and modified existing dead-front construction pad mounted switchgear and pad mounted transformers.

Provide connectors in kit form, which are the product of a single manufacturer, and compatible with both the cable and equipment bushing on which the connector is applied. Connectors shall have a steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material per IEEE 386. Provide a hot line voltage indicator on each connector installed as part of this project. Provide LED type hot line voltage indicators which are the product of a single manufacturer, and compatible with the connector on which the hot line voltage indicator is applied. Provide connectors with ratings as follows:

15kV 200 Ampere Load-break Connectors: BIL impulse withstand 1.2 x 50 microsecond wave: 95kV. Short time rating: 10,000 amperes rms, symmetrical for a time duration of 0.17 seconds and 3,500 amperes rms, symmetrical for a time duration of 3.0 seconds.

15kV 600 Ampere Dead-break Connectors: BIL impulse withstand 1.2 x 50 microsecond wave: 95kV. Short time rating: 40,000 amperes rms, symmetrical for a time duration of 2.0 seconds and 27,000 amperes rms, symmetrical for a time duration of 4.0 seconds. Where piggyback mount surge arresters are specified to be installed, provide 15kV 200 ampere bushing.

2.5 SPLICES

Provide splices in kit form, which are the product of a single manufacturer, compatible with the cable on which the splice is applied, and meeting the requirements in the paragraph entitled, "Splices and Terminations," of this section. Splices shall be suitable for use in the environment in which the splice is installed. Provide splices for use on 15kV cable as follows:

a. 15kV Cable Splices: Splices for 15kV EPR concentric neutral cable shall be heat-shrink type specifically designed for NASA cable and grounding provisions which include but is not limited to the following: inner heat shrink stress control tube with external end sealant, additional heat shrink tube over inner tube and inner tube end sealant, heat shrink outer wraparound sleeve with heat sensitive indications on both the tube and tail/channel area to indicate proper torch heating, stress relief material, mastic, sealant, shielding mesh, and silicon grease.

2.6 TERMINATIONS

Provide Class 1 terminations per IEEE 48 in kit form, which are the product of a single manufacturer, compatible with both the cable and equipment spade terminal on which the termination is applied, and meeting the requirements in the paragraph entitled, "Splices and Terminations," of this section. Terminations shall employ copper 2-hole long barrel irreversible compression type lugs installed using the termination manufacturer's required tooling.

2.7 CABLE TAGS

Provide cable tags as specified and detailed on the drawings. Provide cable tags on each new medium voltage cable, and cable splice as part of this project. Provide a cable tag on each individual cable in each location where the cable is accessible (e.g. manhole, junction boxes, termination points). Cable tags shall be polyethylene. Handwritten legends are not acceptable.

2.7.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of4500 pounds per square inch, and are 0.035-inch thick, non-corrosive non-conductive. Ensure tags are resistive to acids, alkalis, organic solvents, salt water, and are distortion resistant to300 degrees F. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ensure ties have a minimum loop tensile strength of 175 pounds. Provide cable tags with black block letters, numbers, and symbols 1-inch high on a yellow background. Ensure letters, numbers, and symbols do not fall off or change positions regardless of the cable tags orientation.

2.8 FIREPROOF TAPE

Provide fireproof tape approximately 30 mils thick by 3 inches wide, consisting of a flexible, unsupported elastomer that expands in fire to provide a thick char buildup between the flame and the cable. Ensure the tape does not give off a smoke when subjected to flames or support combustion. Also, ensure tape does not deteriorate when subjected to oil, water, gases, salt water, sewage and fungus.

2.9 FACTORY TESTING

Submit certified evidence that the cable manufacturer has made factory-conducted tests on each shipping length (reel) of cable. Submit certified copies of test data in accordance with applicable provisions of the referenced standard. Include in tests on each length of cable, conductor resistance; ionization; high voltage; partial discharge test. Contracting Officer or designee has the option of witnessing required factory testing at no additional cost. Provide a schedule of manufacturing and testing in advance to permit such witnessing, if requested.

Submit certified qualification test reports in accordance with AEIC CS8 made in accordance with the applicable referenced standards. Ensure certified copies of test data show conformance to the requirements of referenced standards and submit for approval prior to shipment of the cable.

Prior to manufacturing, provide data regarding degradation of proposed insulating material and cable performance due to water immersion test as specified in this specification to the Contracting Officer or designee. Indicate in information AC breakdown stress in kV/mm or V/mil versus immersion time. Ensure a complete description and condition under which cable was tested accompanies the test information. Submit an accelerated water absorption test.

PART 3 EXECUTION

3.1 CABLE CUTTING AND SPLICING

The Government has established a mandatory inspection point prior to Contractor performing any medium voltage cable cuts or splicing. Notify the Contracting Officer 48 hours in advance of this mandatory inspection point.

As part of the mandatory inspection point, positively identify and label the medium voltage cable and splice it as required by the scope of work. Ensure the process of identifying and labeling the cable to be worked is witnessed by the Government. Cable cutting and splicing of a medium voltage cable can occur only after approval by the Contracting Officer.

3.2 INSTALLATION

Install medium-voltage cables in accordance with NESC and NFPA 70.

Refer to contract provisions for safety submittals and requirements associated with working in the vicinity of energized cables in manholes and at equipment. The use of arc-flash and shock prevention equipment and personal protective equipment is mandatory.

3.2.1 Protection During Splicing Operations

Provide blowers to force fresh air into manholes or confined areas where free movement or circulation of air is obstructed. Ensure waterproof protective coverings are available on the work site to provide protection against moisture while a splice is being made. Under no conditions, make a splice or termination with the interior of a cable exposed to moisture. Moisture-test conductor insulation paper before the splice is made.

3.2.2 Pulling Cables in Ducts and Manholes

3.2.2.1 Pulling Procedures (NOT USED)

3.2.3.2 Allowable Sidewall Pressure (NOT USED)

3.2.3.3 Minimum Bending Radius

Minimum bending radius during cable pulling operations is 30 inches. For permanent cable bending/racking the minimum bending radius is 12 times cable diameter.

3.2.3.4 Coating of Cables (NOT USED)

3.2.3.5 Pulling Speed (NOT USED)

3.2.3.6 Cable Splice Support and End Sealing

Firmly support cable splices made up in manholes on cable racks as indicated. Do not pull ON cable splices.

Immediately seal cut ends of cables cut in the field to prevent entrance of moisture with heat-shrinkable molded cable end caps.

3.2.4 Splices and Terminations

Field fabricate terminations from termination kits supplied by, and in accordance with, the termination manufacturer's recommendations for the type, size, and electrical characteristics of the cable specified.

Make splices in manholes as shown on the drawings. Make cable terminations at equipment specifically indicated. Expedite splicing and terminating of cables to minimize exposure and cable deterioration.

Field fabricate cable splices from heat-shrinkable splicing kits supplied by, and in accordance with, the cable manufacturer's recommendations for the type, size, and electrical characteristics of the cable specified. Locate cable splices in manholes midway between cable racks on walls of manholes and supported with cable arms at approximately the same elevation as the enclosing duct.

Use tools recommended by the splice manufacturer including calibrated cutting equipment to ensure consistent cut depths when preparing cable ends for the application of the splice kit. Submit a list of manufacturer's recommended tools for splicing operations. Connect the cable concentric neutral/shield wires across one side of the splice by split bundling the splice neutral wiring and connecting each bundle set to a continuous No. 4 AWG solid bare copper conductor via two compression conductors. Ensure the No. 4 AWG conductor extrudes from the cable splice jacket and connects to the manholes grounding system. Make all connections within the splice utilizing long barrel-type compression connectors and appropriate compression tools with proper size dies to ensure a satisfactory mechanical and electrical joint. Ensure bare connections of concentric neutral/shield wires are either contained within the splice kit or sealed via an additional outer covering, consisting of a heavy wall, heat-shrinkable tubing containing adhesive material (mastic) that melts as heat is applied and the outer tubing shrinks to form a moisture proof environmental seal. Provide outer tubing conforming to ANSI C119.1. Ensure splice meets the requirements of IEEE 404 for 15kV ratings, as applicable, and is rated by the manufacturer for use on 15kV class feeder cable systems, as applicable. Take extra precautions to seal around the exit area of the bare copper jumpers with an additional mastic per the splice manufacturer's recommendations.

Terminate cables in approved cable terminations, rated Class 1 per IEEE 48. Dry terminations with medium voltage pennants, preformed, and hand wrapped stress cones can be used for terminating cables. Provide terminations with adequate means for making external connections to the cable conductors of single-conductor cables (phase and concentric neutral), protecting the cable insulation against moisture, oil, or other contaminants. Take extra precautions in physically protecting and supporting cables, and maintaining the insulation level of the cable.

Include in installation built-up or prefabricated heat or cold shrink stress-relief cones at the terminals of all shielded cables and at the terminals of single-conductor lead-covered cables rated 15 kV and above.

Install cable splices on cable racks so as to minimize the physical stress on the splice connections. Support splices at approximately the same elevation as the installed cable, except where space limitations or existing cable length limitations make this method impractical or impossible.

Support all universal demountable splices in such manner so as to minimize physical stress on the splice connections. Support each cable end termination using a pair of saddle type supports under the cable end termination and/or cable with a minimum 12 inches and a maximum 30 inches

separation between the supports. Secure cable end termination and cable to the supports in such a manner as to prevent movement of termination or cable at the support. Install saddle type supports on galvanized steel framing channel anchored to the wall or securely fastened to the cable tray or installed by other approved methods.

Concentric neutral conductors of medium voltage cable systems shall be bonded to all manhole ground systems at splice locations and to both the equipment enclosure and its earth ground system at all terminations.

3.2.5 Fireproofing

Provide fireproofing (Arc Proofing) for individual cable conductor in manholes, which carry current at 2200 volts or more.

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Extend the tape 1 inch into the ducts. To prevent unraveling, random wrap the fireproofing tape the entire length of the fireproofing with pressure-sensitive glass cloth tape.

3.2.6 Cable Tag Installation

Install cable tags on each cable installed as part of this project, and at each termination. Install cable tags over the fireproofing and position the tags so that they are clearly visible without disturbing any other cabling or wiring.

3.3 FIELD TESTING

After the installation of power cables has been completed, including splices, and terminations, the test laboratory will test the cable as specified in the test lab scope.

3.4 ATTACHMENT

Attachment-1: Typical Splice photograph.

-- End of Section --

ATTACHMENT 10 – PRODUCT DATA

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Type SCV-D Current Transformer

600 Volt, 10 kV BIL, Indoor

Product Bulletin 1VAP428602-DB

Product Features

- 600 Volt Indoor
- 10 kV BIL
- 25 through 400 Hertz
- Primary Amperes 50-4000
- Mechanical Rating
  180 x rated current
- Thermal Rating
  80 x rated current, one second
- Continuous Current Rating Factor
  Refer to Selection Guide
- UL Recognized Component,
  File No. E96461

UL Recognized Component

Application

The SCV-D deep case current transformer is used in metal clad vacuum and SF6 switchgear (5 kV through 27 kV) as the source of current for extended relaying and metering applications.

Construction Features

The ring-type core is insulated and toroidally wound with a fully distributed secondary winding. The protective case, made of an impact-resistant polycarbonate, is assembled using self-tapping screws.

Secondary Terminals

Secondary terminals are 10-32 brass terminal screws with hardware. Space is available for a maximum of five terminals to accommodate multi-ratio designs.

Curves

Saturation, overcurrent, ratio correction factor, and phase-angle curves are available upon request.

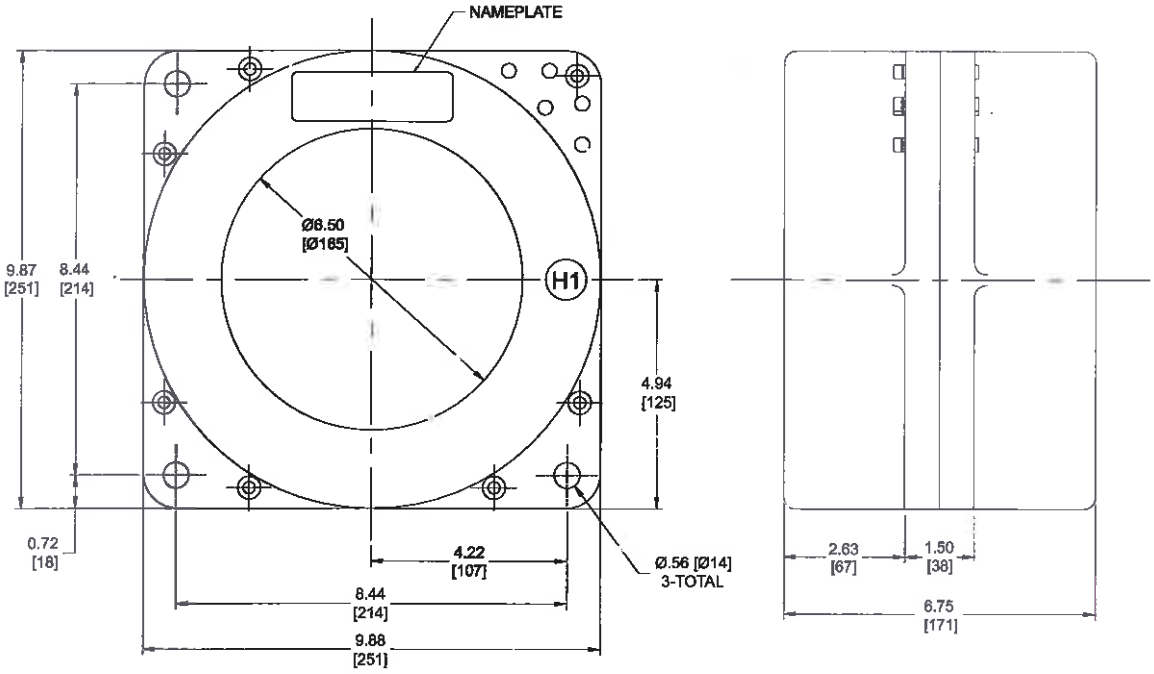
Test Reports

IEEE test reports are stored electronically and can be e-mailed in various formats at the time of shipment.

Standards

This unit meets all applicable IEEE and NEMA standards and is a UL Recognized Component.

Unit Dimensions



Approximate weight is 48 lbs.

Note: Metric dimensions are displayed in [mm].

Primary Ampere Rating	Continuous Current Rating Factor		IEEE Metering Accuracy					IEEE Relaying Accuracy	Style Number
	30 °C	55 °C	B-0.1	B-0.2	B-0.5	B-0.9	B-1.8		
Type SCV-D (6.5" window)									
50	2.0	1.5	1.2	2.4	-	-	-	C10	6353C89H01
75	2.0	1.5	1.2	1.2	2.4	-	-	C20	6353C89H02
100	2.0	1.5	0.6	1.2	2.4	-	-	C20	6353C89H03
150	2.0	1.5	0.6	0.6	1.2	2.4	-	C50	6353C89H04
200	2.0	1.5	0.3	0.3	0.6	1.2	2.4	C50	6353C89H05
250	2.0	1.5	0.3	0.3	0.6	1.2	2.4	C50	6353C89H06
300	2.0	1.5	0.3	0.3	0.3	0.6	1.2	C100	6353C89H07
400	2.0	1.5	0.3	0.3	0.3	0.6	0.6	C100	6353C89H08
500	2.0	1.5	0.3	0.3	0.3	0.3	0.6	C100	6353C89H09
600	2.0	1.5	0.3	0.3	0.3	0.3	0.6	C200	6353C89H10
800	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C200	6353C89H11
1000	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C200	6353C89H12
1200	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6353C89H13
1500	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6353C89H14
2000	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6353C89H15
2500	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6353C89H16
3000	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6353C89H17
4000	1.33	1.0	0.3	0.3	0.3	0.3	0.3	C400	6353C89H18
5000	1.0	0.75	0.3	0.3	0.3	0.3	0.3	C400	7525A37G23
6000	1.0	0.75	0.3	0.3	0.3	0.3	0.3	C400	7525A37G19
Multi-Ratio, IEEE, 5 Terminals									
600	2.0	1.5	0.3	0.3	0.3	0.3	0.6	C200	6436C46H01
1200	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6436C47H01
2000	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6436C48H01
3000	2.0	1.5	0.3	0.3	0.3	0.3	0.3	C400	6436C49H01
4000	1.33	1.0	0.3	0.3	0.3	0.3	0.3	C400	6436C50H01
5000	1.0	0.75	0.3	0.3	0.3	0.3	0.3	C400	7525A39G06
6000	1.0	0.75	0.3	0.3	0.3	0.3	0.3	C400	7525A39G11

Additional styles available upon request. Contact your ABB Sales Representative or call +1-252-827-3212 for more information.

ABB Inc.
3022 NC 43 North
Pinetops, NC 27864
Tel: +1-252-827-3212
www.abb.com/mediumvoltage

instrument transformers

Types VIZ-75 and VIZ-11
Indoor voltage transformers

Product features
- 8.3 and 15 kV indoor
- 75 and 110 kV BIL, 60 Hertz
- Primary volts: 2400 - 14400
- UL Recognized Components, File No. E148620

Application
The VIZ-75 and VIZ-11 indoor voltage transformers are designed for service in metalclad switchgear and are used for metering, relaying, or control power. Both units are available in single, double, and tapped secondary designs with two accuracy and thermal rating options.

Construction features
The primary and secondary coils are wound using special winding and shielding techniques for improved voltage stress distribution. The coils are designed to withstand continuous operation at either 1.1 or 1.25 times the line-to-line voltage level for Z burden units and 1.9 times the line-to-ground voltage level for Y burden units.

Each coil is insulated with mylar film to provide a high dielectric strength between layers. The coils and core are combined to create a complete winding structure that is assembled to a support frame. The entire assembly is vacuum cast in polyurethane for added insulation and protection.

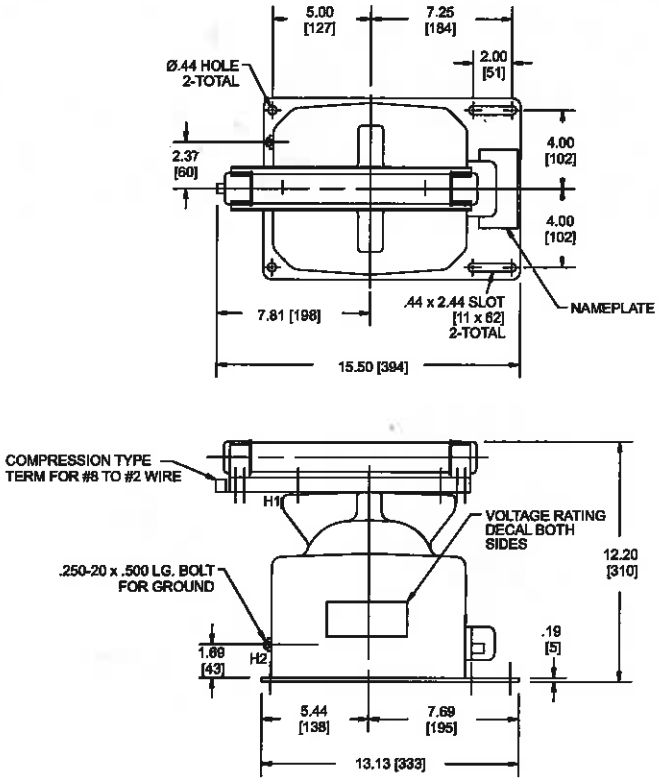
Fuse classifications
These units are provided with three fuse classifications: mounted fuse with hardware, unfused with hardware, or unfused without hardware. Optional fuse kits are offered to convert unfused styles to fused styles.

Mounting
The VIZ-75 and VIZ-11 can be mounted in upright, cantilever, or upside-down positions.

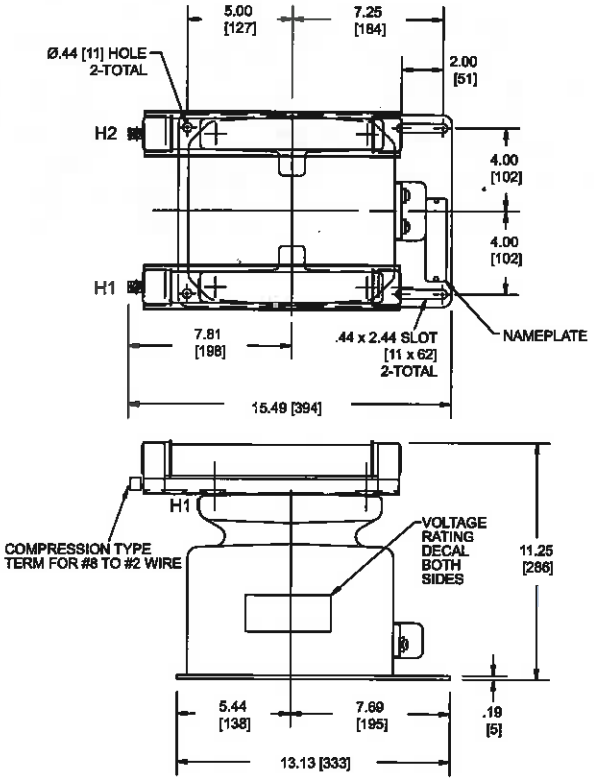
Test reports
IEEE test reports are stored electronically and can be e-mailed in various formats at the time of shipment.

Standards
These units meet all applicable IEEE and NEMA standards and are UL Recognized Components.

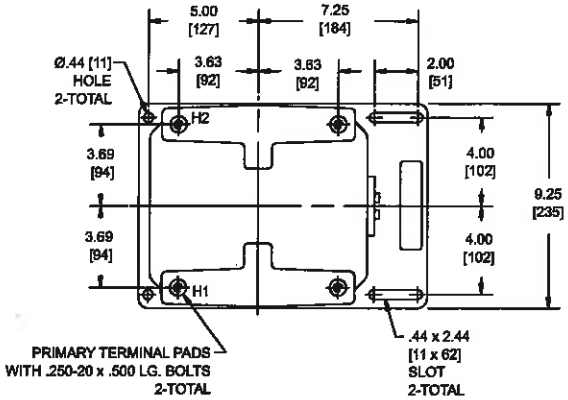
Unit dimensions

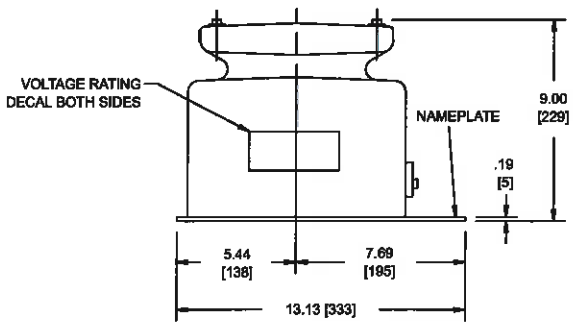


Fused (one fuse), approximate weight 67 lbs.

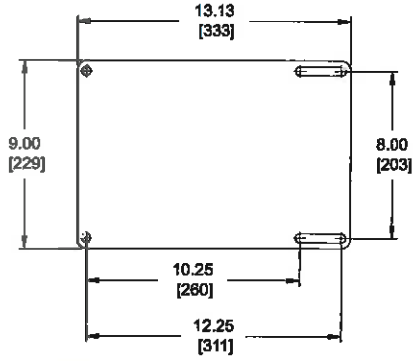


Fused (two fuses), approximate weight 69 lbs.





Unfused, approximate weight 65 lbs.



Baseplate dimensions

Optional accessories

Fuse kits to convert unfused VIZ-75 or VIZ-11 to fused style:

- For line-to line units:
  Fuse kit (two fuses and hardware) 7527A98G01
- For line-to ground units:
  Fuse kit (one fuse and hardware) 7527A98G02

Replacement fuses:

- CLE-PT, 0.5, 15.5 kV: 50C5225G03
- CLE-PT, 1.0, 15.5 kV: 50C5225G08

Selection guide for line-to-line units

Primary voltage	Secondary voltage	Winding ratio	Rated voltage factor	Frequency	Style number: Unfused with no provision for fuse mounting	Style number: Two fuses	Style number: Unfused with provision for fuse mounting
VIZ-75 line-to-line							
2400/4160Y	120	20:1	1.1	60	7525A66G01	7525A67G01	7525A70G01
4200/7280Y	120	35:1	1.1	60	7525A66G02	7525A67G02	7525A70G02
4800/8320Y	120	40:1	1.1	60	7525A66G03	7525A67G03	7525A70G03
7200/7200Y	120	60:1	1.1	60	7525A66G04	7525A67G04	7525A70G04
7200/7200Y	120	60:1	1.1	50	-	7525A67G18	7525A70G18
VIZ-11 line-to-line							
7200/12470Y	120	60:1	1.1	60	7525A66G05	7525A67G05	7525A70G05
7620/13200Y	120	63.5:1	1.1	60	7525A66G06	7525A67G06	7525A70G06
8400/14560Y	120	70:1	1.1	60	7525A66G07	7525A67G07	7525A70G07
12000/12000Y	120	100:1	1.1	60	7525A66G08	7525A67G08	7525A70G08
13200/13200Y	120	110:1	1.1	60	7525A66G09	7525A67G09	7525A70G09
14400/14400Y	120	120:1	1.1	60	7525A66G10	7525A67G10	7525A70G10
11000/11000Y	110	100:1	1.1	50	-	7525A67G11	-
2400/4160Y	120	20:1	1.1	60	-	7525A67G17	7525A70G17
12000/12000Y	120	100:1	1.1	50	7525A66G13	7525A67G15	7525A70G15
14400/14400Y	120	120:1	1.1	50	-	7525A67G34	7525A70G14
12470/12470Y	120	103.9:1	1.1	60	7525A66G15	7525A67G38	7525A70G27
13800/13800Y	120	115:1	1.1	60	-	7525A67G43	7525A70G37
13800/13800Y	115	120:1	1.1	60	7525A66G11	7525A67G58	-
10000/10000Y	120	83.33:1	1.1	60	-	7525A67G35	7525A70G28

Selection guide for line-to-ground units

Primary voltage	Secondary voltage	Winding ratio	Rated voltage factor	Frequency	Style number: One fuse	Style number: Unfused with provision for fuse mounting
VIZ-75 line-to-ground						
2400/4160GY	120	20:1	1.1	60	7525A68G01	7525A71G01
4200/7280GY	120	35:1	1.1	50	7525A68G26	-
4200/7280GY	120	35:1	1.1	60	7525A68G02	7525A71G02
7200/7200GY	120	60:1	1.1	50	7525A68G34	-
4800/8320GY	120	40:1	1.1	60	7525A68G03	7525A71G03
7200/7200GY	120	60:1	1.1	60	7525A68G04	7525A71G04
VIZ-11 line-to-ground						
14400/14400GY	120	120:1	1.1	50	7525A68G14	7525A71G15
14400/14400GY	120	120:1	1.1	60	7525A68G10	7525A71G10
8400/14560GY	120	70:1	1.1	50	7525A68G15	7525A71G18
15000/15000GY	120	125:1	1.1	60	7525A68G21	-
4200/7280GY	120	35:1	1.1	60	7525A68G31	-
10000/10000GY	120	83.33:1	1.1	60	7525A68G36	-
10000/10000GY	120	83.33:1	1.1	50	7525A68G37	-
11000/11000GY	120	91.67:1	1.1	50	7525A68G42	-
13800/13800GY	115	120:1	1.1	60	7525A68G44	-
7620/13200GY	208.75	63.5:1	1.1	60	7525A68G50	-
2400/4160GY	120	20:1	1.1	60	7525A68G55	-
13800/13800GY	120	115:1	1.1	60	7525A68G61	-
7200/12470GY	120	60:1	1.1	60	7525A68G05	7525A71G05
7620/13200GY	120	63.5:1	1.1	60	7525A68G06	7525A71G06
8400/14560GY	120	70:1	1.1	60	7525A68G07	7525A71G07
12000/12000GY	120	100:1	1.1	60	7525A68G08	7525A71G08
13200/13200GY	120	110:1	1.1	60	7525A68G09	7525A71G09
7200/12470GY	120	60:1	1.1	50	7525A68G63	7525A71G12
12000/12000GY	120	100:1	1.1	50	7525A68G17	7525A71G13

Additional styles available upon request. Contact your ABB sales representative or call +1-252-827-3212 for more information.

1VAP429651-DB February 2012 Rev. B

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UL Recognized Component, File No. E148620

Power and productivity
for a better world™

Deadbreak Apparatus Connectors

COOPER Power Systems

600 A 15/25 kV Class Separable Splices

GENERAL

Cooper Power Systems 600 A, 15/25 kV Class Deadbreak Separable Splices are used to splice two, three or four cables or to deadend a single cable. They are fully shielded, submersible and meet the requirements of IEEE Std 386™ standard – Separable Insulated Connector Systems. The splices are rated for 600 A or 900 A and are suitable for the repair or extension of underground feeders. Installed either direct buried or in a vault, 600 A separable splices can be used on all 15 and 25 kV Class power distribution systems. They are made of high quality peroxide cured EPDM rubber to provide excellent electrical, thermal and mechanical reliability. All have 5/8 inch-11 UNC 2A aluminum threads that meet IEEE Std 386™ standard requirements for 600 A separable connections. Optional all copper components are also available.

The capacitive test point on the insulating plug provides a means of testing the circuit without disturbing the bolted connection.

In addition to the capacitive test point feature on the insulating plug, Cooper offers an optional capacitive test point similar to the test points on Cooper 200 A Elbows. This allows the use of the Type "TPR" Series Fault Indicators and provides a hotstick operable means of determining the circuit condition when used with a high impedance voltage sensing device designed for test points.

Separable splices and deadends are designed for use on solid dielectric cable (XLPE or EPR) with extruded semiconductive shields and concentric neutral, with or without a jacket. Installation on jacketed concentric neutral cable may require additional sealing material. Cold shrinkable adapters are available for tape shield, linear corrugated and drain wire cable adaptation for use with separable splices.

900 AMP RATING

Separable splices are rated for 900 A continuous when used with a copper-top compression connector (ordered separately), copper insulating plug, copper connecting plug, and copper stud. If a 900 A rating is desired, specify a "C" as the 8th digit when determining your part number (See Table 3, page 3.)

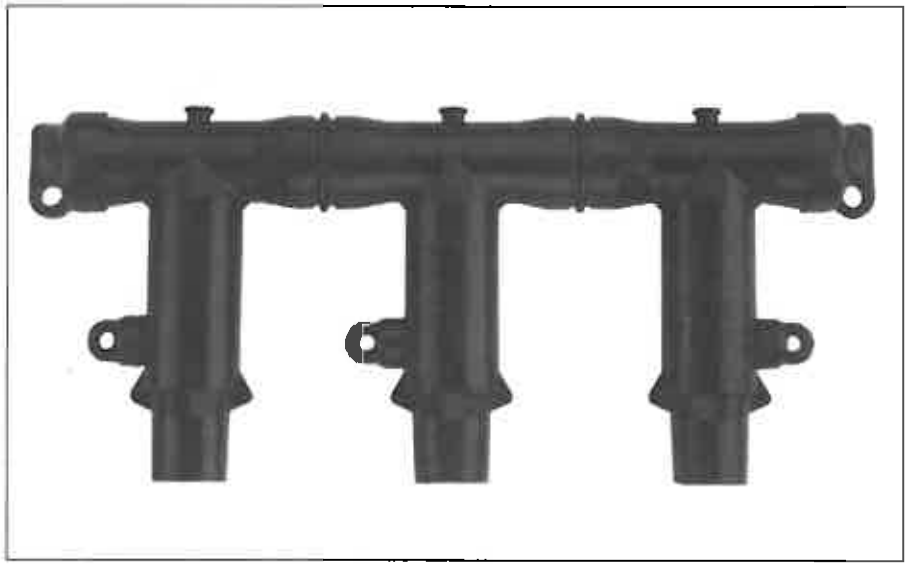


Figure 1.
600 A 15/25 kV Class Separable Splice (3 way splice shown).

INSTALLATION

The T-Body splice housings are assembled onto prepared cable with spade lug compression connectors. The rubber connecting plugs used to connect the housings are tightened using a torque wrench, 1" socket, and a 5/16" hex drive. Refer to Installation Instruction Sheet S600-10-2 for details.

INTERCHANGEABILITY

All Cooper 600 A Deadbreak Connectors conform to the electrical, mechanical and dimensional requirements of IEEE Std 386™ standard. The connectors can be used on any comparably rated bushing interface that also meets the requirements of this standard. In addition, all cable adapters, insulating plugs, compression connectors and other component parts are designed to be interchangeable with those currently available from other major manufacturers.

PRODUCTION TESTS

Tests conducted in accordance with IEEE Std 386™ standard:

- AC 60 Hz 1 Minute Withstand – 40 kV
- Minimum Partial Discharge Extinction Voltage – 19 kV
- Test Point Voltage Test

Tests conducted in accordance with Cooper Power Systems requirements:

- Physical Inspection
- Periodic Dissection
- Periodic X-ray Analysis

TABLE 1
Voltage Ratings and Characteristics

Description	kV
Standard Voltage Class	25
Maximum Rating Phase-to-Ground	15.2
AC 60 Hz 1 Minute Withstand	40
DC 15 Minute Withstand	78
BIL and Full Wave Crest	125
Minimum Partial Discharge Extinction Voltage	19

Voltage ratings and characteristics are in accordance with IEEE Std 386™ standard.

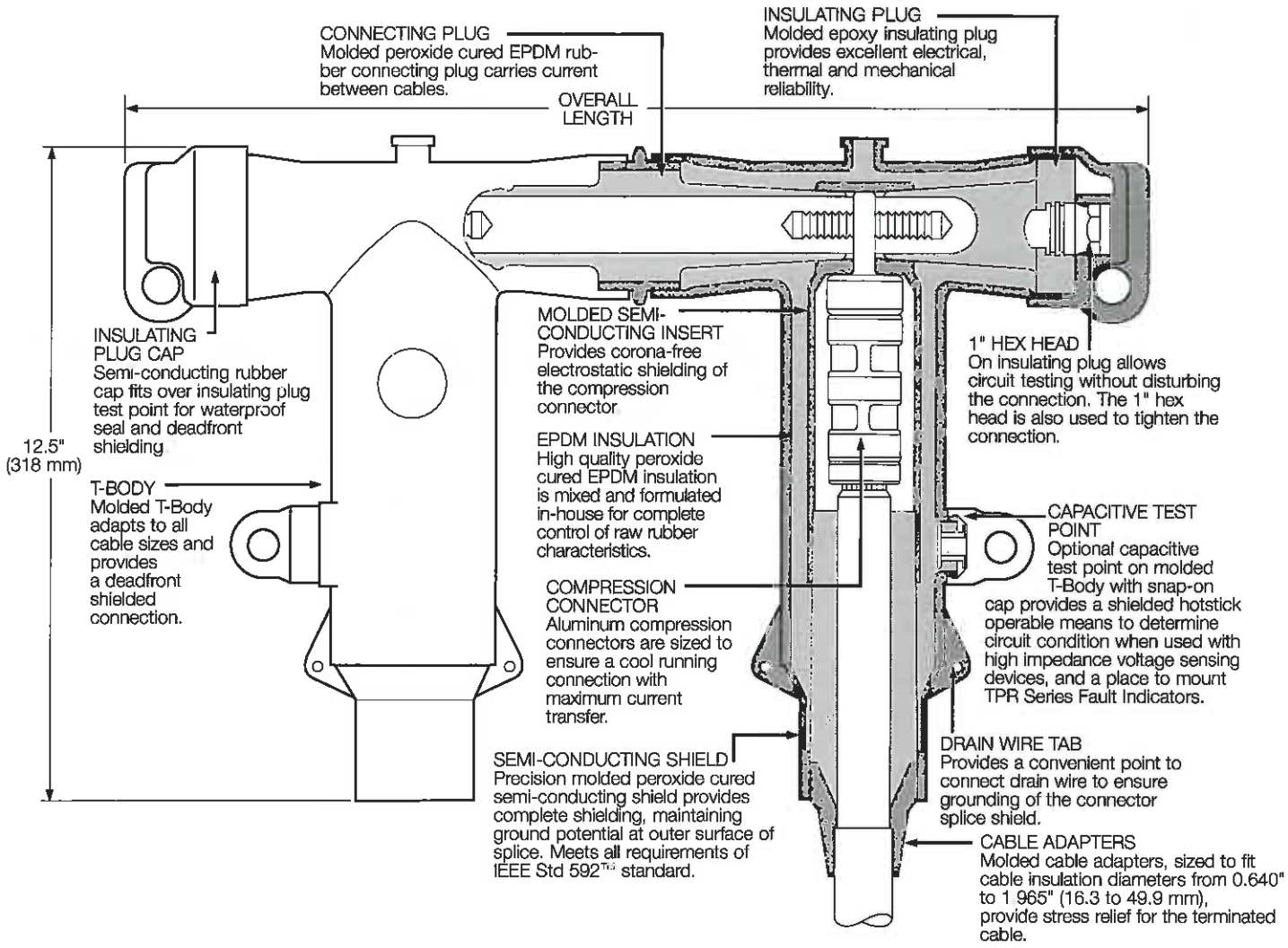


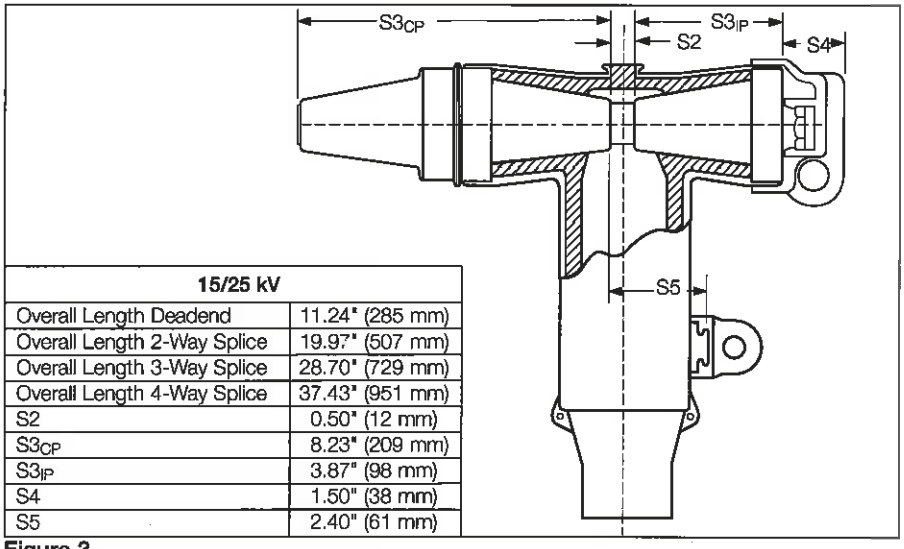
Figure 2.
Illustration shows design characteristics and 2-way splice connection.

Note: Dimensions given are for reference only.

TABLE 2
Current Ratings and Characteristics

Description	Amperes
Continuous	600 A rms
24 Hour Overload	1,000 A rms
Short Time	40,000 A rms symmetrical for 0.17 s 27,000 A rms symmetrical for 4.0 s

Current ratings and characteristics are in accordance with IEEE Std 386™standard.



15/25 kV	
Overall Length Deadend	11.24" (285 mm)
Overall Length 2-Way Splice	19.97" (507 mm)
Overall Length 3-Way Splice	28.70" (729 mm)
Overall Length 4-Way Splice	37.43" (951 mm)
S2	0.50" (12 mm)
$S3_{CP}$	8.23" (209 mm)
$S3_{IP}$	3.87" (98 mm)
S4	1.50" (38 mm)
S5	2.40" (61 mm)

Figure 3.
Separable Splice stacking dimensions.

ORDERING INFORMATION

To order a Cooper 600 A, 15/25 kV Deadend or Separable Splice kit, specify separate catalog numbers for:

- Basic Kit
- Each Compression Connector
- Each Cable Adapter
- One 5/16" Hex Drive HD625 (Figure 5)

Components included in separable splice kits and components that must be ordered separately are indicated in Table 5.

Each kit contains:

- Silicone Lubricant
- Installation Instruction Sheet

Example:

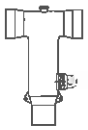
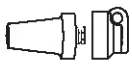
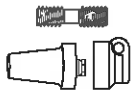
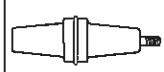
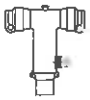
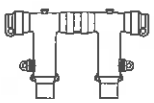
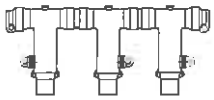
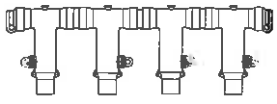
For a 3-Way cable splice without capacitive test points, with aluminum components for three different size cables, specify SSPL625A3 for the basic kit, three additional catalog numbers for the three compression connectors, three catalog numbers for the three cable adapters, and the number for the 5/16" Hex Drive, or a total of eight catalog numbers.

TABLE 3
Separable Splice Kits

Description	Catalog No.	Description	Catalog No.
Deadend Kit		**3-Way Splice Kit**	
Aluminum Components without Test Point	SSPL625A1	Aluminum Components without Test Point	SSPL625A3
Copper Components without Test Point	SSPL625C1	Copper Components without Test Point	SSPL625C3
Aluminum Components with Test Point	SSPL625A1T	Aluminum Components with Test Point	SSPL625A3T
Copper Components with Test Point	SSPL625C1T	Copper Components with Test Point	SSPL625C3T
2-Way Splice Kit		**4-Way Splice Kit**	
Aluminum Components without Test Point	SSPL625A2	Aluminum Components without Test Point	SSPL625A4
Copper Components without Test Point	SSPL625C2	Copper Components without Test Point	SSPL625C4
Aluminum Components with Test Point	SSPL625A2T	Aluminum Components with Test Point	SSPL625A4T
Copper Components with Test Point	SSPL625C2T	Copper Components with Test Point	SSPL625C4T

Note: Studs are bagged and loose in kit. To have studs permanently installed at the factory, add a "P" at the end of the part number.

TABLE 4
Separable Splice Kits

Assembly	Each Splice Kit Contains:				Order Separately:	
					See Table 6	See Table 7
	 T-Body	 Insulating Plug with Cap	 Insulating Plug with Cap and Stud	 Connecting Plug with Stud	 Cable Adapter	 Compression Connector
 Deadend	1	1	1	—	1	1
 2-Way Splice	2	1	1	1	2	2
 3-Way Splice	3	1	1	2	3	3
 4-Way Splice	4	1	1	3	4	4

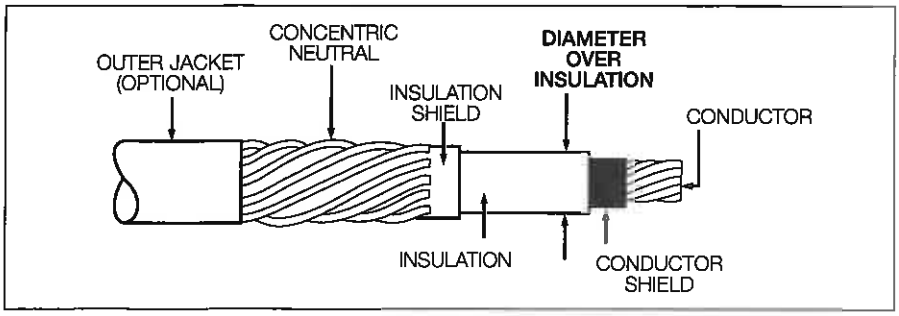


Figure 4.
Cable cutaway showing conductor and insulation layers.

ORDERING INFORMATION

Cable Adapter

To order cable adapters, refer to Table 6. These cable adapters are for use on the BOL-T, T-OP II, BT-TAP, Separable Splices and PUSH-OP Connection Systems.

Determine the cable diameter over the high-voltage insulation and specify the catalog number using Table 5. Minimum and maximum cable insulation diameter must fall within the range of the appropriate cable adapter as AEIC cable diameter can vary ± 0.030".

Example: To order a cable adapter of 1.200 inches, determine the cable diameter range as follows:

1.200 - 0.030=1.170 minimum diameter

1.200 + 0.030=1.230 maximum diameter

Therefore, specify **CA625EE.**

TABLE 5
Cable Adapter

Cable Diameter Range		
Inches	mm	Code
0.610-0.970	15.5-24.6	AB
0.750-1.080	19.1-27.4	CC
0.970-1.310	24.6-33.3	DD
1.090-1.470	27.7-37.3	EE
1.260-1.640	32.0-41.7	FF
1.360-1.710	34.5-43.4	GG
1.510-1.850	38.4-47.0	HH
1.700-1.970	43.2-50.0	JJ

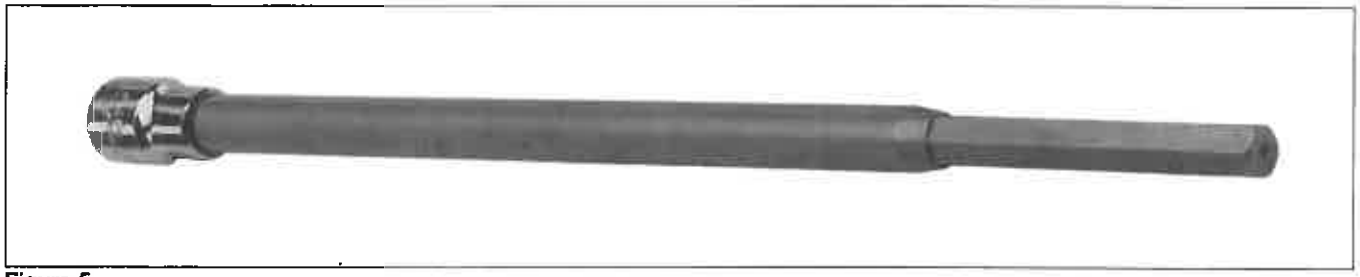


Figure 5.
HD625 Hex Drive.

ORDERING INFORMATION

Compression Connectors

TABLE 6
Replacement Parts

Conductor Size				Catalog Number		
Concentric or Compressed		Compact or Solid				
mm²	AWG or KCMIL	mm²	AWG or KCMIL	15/16 in. ~ 9 Threaded Coppertop	11/16 in. Unthreaded Aluminum	11/16 in. Unthreaded Coppertop
–	2	–	1	CC6C11T	CC6A11U	CC6C11U
–	1	–	1/0	CC6C12T	CC6A12U	CC6C12U
50	1/0	70	2/0	CC6C13T	CC6A13U	CC6C13U
70	2/0	–	3/0	CC6C14T	CC6A14U	CC6C14U
–	3/0	95	4/0	CC6C15T	CC6A15U	CC6C15U
95	4/0	120	250	CC6C16T	CC6A16U	CC6C16U
120	250	–	300	CC6C17T	CC6A17U	CC6C17U
–	300	–	350	CC6C18T	CC6A18U	CC6C18U
–	350	185	400	CC6C19T	CC6A19U	CC6C19U
185	400	–	450	CC6C20T	CC6A20U	CC6C20U
–	450	240	500[a]	CC6C21T	CC6A21U	CC6C21U
240	500	300	600	CC6C22T	CC6A22U	CC6C22U
300	600	–	700	CC6C23T	CC6A23U	CC6C23U
–	650[b]	–	750[c]	CC6C24T	CC6A24U	CC6C24U
–	750[d]	–	900	CC6C25T	CC6A25U	CC6C25U
–	900	500	1000	CC6C26T	CC6A26U	CC6C26U
500	1000	–		CC6C27T	CC6A27U	CC6C27U

a. Also accepts 550 kcmil compact conductor.
b. Also accepts 700 kcmil compressed conductor.
c. Also accepts 800 kcmil compact conductor.
d. Also accepts 700 kcmil concentric conductor.

TABLE 7
Replacement Parts

Description	Catalog Number
T-Body without Test Point	DT625
T-Body with Test Point	DT625T
Insulated Plug Cap	DIPCAP
Aluminum Insulating Plug with Cap, No Stud	DIP625A
Copper Insulating Plug with Cap, No Stud	DIP625C
Aluminum Insulating Plug with Cap and Aluminum Stud*	DIP625AS
Copper Insulating Plug with Cap and Copper Stud*	DIP625CS
Aluminum Connecting Plug, No Stud	DCP625A
Copper Connecting Plug, No Stud	DCP625C
Aluminum Connecting Plug, With Aluminum Stud*	DCP625AS
Copper Connecting Plug, With Copper Stud*	DCP625CS
5/8 in. - 11 UNC 2A Aluminum Threaded Stud	STUD-A
5/8 in. - 11 UNC 2A Copper Threaded Stud	STUD-C
5/16 in. Hex Shaft with 3/8 in. Socket Drive Tool	HD625

* Studs are bagged and loose in kit. To have studs permanently installed at the factory, add a "P" at the end of the part number.

ACCESSORIES

See Catalog Section 600-46 for further information on Replacement Parts and Accessories.

COOPER Power Systems

2300 Badger Drive
Waukesha, WI 53188 USA
www.cooperpower.com

DIVISION 16 – ELECTRICAL
SPECIFICATION # 79K38549
SECTION 16124

MEDIUM VOLTAGE CABLE
2.3 -- SINGLE CONDUCTOR 15KV SHIELDED CABLE
SD-03 PRODUCT DATA

ALSO COVERS

DIVISION 16 – ELECTRICAL
SPECIFICATION # 79K38609
SECTION 26 05 13.00 98

MEDIUM VOLTAGE CABLE
2.3 - SINGLE CONDUCTOR 15KV SHIELDED CABLE
SD-03 PRODUCT DATA

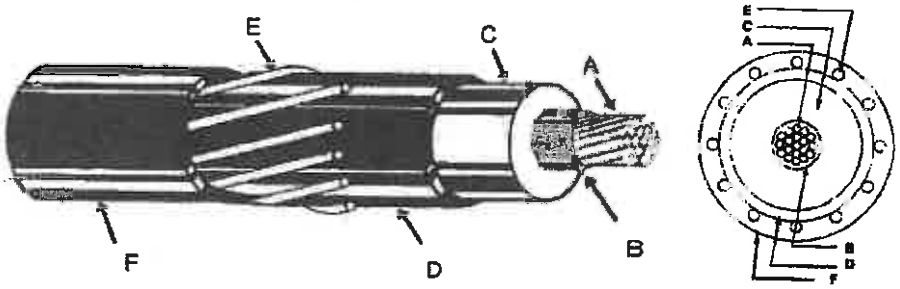
GENERAL CABLE

General Cable

BICC BRAND

Drawing / Data Sheet

Single Conductor EmPowr® Fill Concentric Neutral (Round Wire) Power Cable 15kV



Representative drawing not to scale

Component Description	Thickness (inches) Min.	Nom.*	Max.	Diameter (inches) Min.	Nom.*	Max.
A: Conductor 4/0 AWG Class B Compressed Strand CU Conductor	--	--	--	0.502	0.512	0.522
B: Conductor Shield Semiconducting Thermoset Polymer	0.012	0.018	--	--	0.548	--
C: Insulation Ethylene Propylene Rubber **Insulation Level** 133%	0.210	0.220	0.250	0.955	0.988	1.045
D: Insulation Shield Semiconducting Thermoset Polymer	0.030	0.035	0.060	1.015	1.058	1.145
E: Concentric Neutral / Metallic Shield 20 x 10 AWG Bare Copper Round Wire	--	--	--	--	1.250	--
F: Jacket Extruded-To-Fill Linear Low Density Polyethylene	0.080	0.091	0.000	--	1.432	--
Single Conductor Finished Cable Nominal Weight: 1897 lb/kft *						

* - Nominal Values are Subject to Manufacturing Tolerances; Bold Font Indicates Minimum Average Values

Customer:	CED #1111	**Customer P/N:**	**EA/PC Number:** 882466 Rev. 0
Specification / Standard:	SECTION 16124 Date: 05/01/09	**Prepared By:** WYQUNXN	**Date:** 12/2/2010

General Cable

BICC. BRAND

Electrical Characteristics

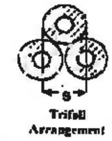
Single Conductor EmPowr® Fill Concentric Neutral (Round Wire) Power Cable 15kV

Cable Description:	4/0 AWG Cu, 0.220" EPR, 20 / 10 AWG Cu, LLDPE

Input Parameters:

Electrical Characteristics Based on

Normal Operating Temperature:	105 C	Dissipation Factor:	0.345 %
IR Constant @ 60°F:	20000	Voltage (line to ground):	8.66 kV
Dielectric Constant:	2.45	Conductor Center to Center Spacing (S):	1.432 in
Earth Resistivity:	100 Ω-m		



Trifoil Arrangement

Conductor Resistance:

Rdc @ 25°C:	0.0510 Ω/kft	0.1672 Ω/km
Rac @ 25°C:	0.0512 Ω/kft	0.1680 Ω/km
Rac @ 105°C:	0.0672 Ω/kft	0.2204 Ω/km

Shield Resistance:

Rac @ 25°C:	0.054 Ω/kft	0.177 Ω/km
Rac @ 100°C:	0.070 Ω/kft	0.228 Ω/km

Capacitance: 0.070 μF/kft — 0.231 μF/km

Shunt Capacitive Reactance/Susceptance:

Shunt Capacitive Reactance:	37655 Ω-kft	11477 Ω-km
Shunt Capacitive Susceptance:	26.56 μS/kft	8.09 μS/km

Charging Current: 230.0 mA/kft — 754.6 mA/km

1-Phase Reactance/Impedance:

Inductive Reactance: 0.025 Ω/kft — 0.0[illegible]3 Ω/km

	Real	Imag.	Impedance	Real	Imag.	Impedance
Pos. & Neg. Seq. Impedance (Met. Shield):	0.067	0.025	0.072 Ω/kft	0.220	0.082	0.235 Ω/km
Zero Seq. Impedance (Earth & Met. Shield):	0.259	0.075	0.269 Ω/kft	0.849	0.247	0.884 Ω/km

3-Phase Reactance/Impedance:

Inductive Reactance: 0.046 Ω/kft — 0.151 Ω/km

	Real	Imag.	Impedance	Real	Imag.	Impedance
Pos. & Neg. Seq. Impedance (Met. Shield):	0.073	0.044	0.085 Ω/kft	0.239	0.145	0.280 Ω/km
Zero Seq. Impedance (Earth & Met. Shield):	0.136	0.032	0.139 Ω/kft	0.445	0.104	0.457 Ω/km
Zero Seq. Impedance (Earth Only):	0.121	0.740	0.750 Ω/kft	0.398	2.427	2.460 Ω/km
Zero Seq. Impedance (Met. Shield Only):	0.137	0.025	0.139 Ω/kft	0.449	0.082	0.456 Ω/km

Dielectric Losses (Per Phase): 6.83 W/kft — 22.43 W/km

Electrical Stress:

Insulation Average:	39.36 V/mil	129.15 kV/mm
Conductor Shield - Insulation Interface Maximum:	53.59 V/mil	175.82 kV/mm
Insulation - Insulation Shield Interface Minimum:	29.72 V/mil	97.52 kV/mm

Insulation Resistance: 5119.53 MΩ-kft — 1560.36 MΩ-km

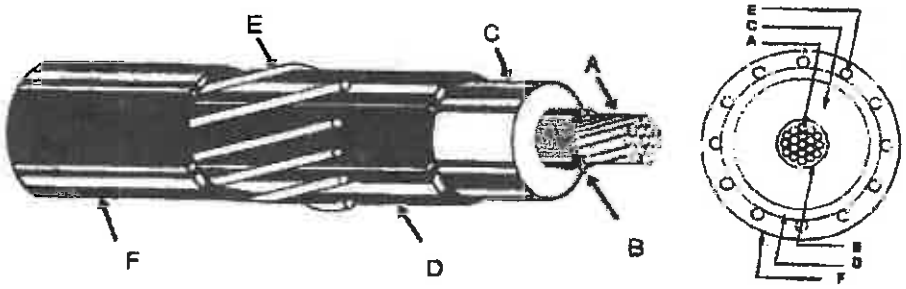
Customer:	CFD #1111	Customer P/N:	GA/GC Number: 862466 Rev. 0
Specification / Standard:	SECTION 16124 Date: 05/01/09	Prepared by: WYQUNXN	Date: 12/2/2010

General Cable

BICC BRAND

Drawing / Data Sheet

Single Conductor EmPowr® Fill Concentric Neutral (Round Wire) Power Cable 15kV



Representative drawing not to scale

Component Description	Thickness (inches) Min	Nom.*	Max	Diameter (inches) Min	Nom.*	Max
A: Conductor 350 kcmil Class B Compressed Strand CU Conductor	--	--	--	0.648	0.661	0.674
B: Conductor Shield Semiconducting Thermoset Polymer	0.016	0.023	--	--	0.707	--
C: Insulation Ethylene Propylene Rubber **Insulation Level** 133%	0.210	0.220	0.250	1.115	1.147	1.200
D: Insulation Shield Semiconducting Thermoset Polymer	0.040	0.045	0.075	1.195	1.237	1.320
E: Concentric Neutral / Metallic Shield 18 x 12 AWG Bare Copper Round Wire	--	--	--	--	1.387	--
F: Jacket Extruded-To-Fill Linear Low Density Polyethylene	0.080	0.091	0.000	--	1.569	--
Single Conductor Finished Cable Nominal Weight: 2160 lb/kft *						

* - Nominal Values are Subject to Manufacturing Tolerances; Bold Font Indicates Minimum Average Values

Customer:	CED # 1111	Customer P/N:	EA/PL Number: 207432 Rev. 0
Specification / Standard:	SECTION 16124 Date: 05/01/09	Prepared By: WYQUNXN	Date: 12/2/2010

General Cable

BICC BRAND

Electrical Characteristics

Single Conductor EmPowr® Fill Concentric Neutral (Round Wire) Power Cable 15kV

Cable Description:	**350 kcmil Cu, 0.220" EPR, 18 / 12 AWG Cu, LLDPE**			
Input Parameters:	**Electrical Characteristics Based on**			
	Normal Operating Temperature:	105 °C	Dissipation Factor:	0.345 %
	IR Constant @ 60°F:	20000	Voltage (line to ground):	8.66 kV
	Dielectric Constant:	2.45	Conductor Center to Center Spacing (S):	1.569 in
	Earth Resistivity:	100 Ω-m		Trifoil Arrangement
Conductor Resistance:		Rdc @ 25°C:	0.0308 Ω/kft	0.1011 Ω/km
		Rac @ 25°C:	0.0312 Ω/kft	0.1024 Ω/km
		Rac @ 105°C:	0.0411 Ω/kft	0.1348 Ω/km
Shield Resistance:		Rac @ 25°C:	0.095 Ω/kft	0.313 Ω/km
		Rac @ 100°C:	0.123 Ω/kft	0.403 Ω/km
Capacitance:			0.086 µF/kft	0.282 µF/km
Shunt Capacitive Reactance/Susceptance:		Shunt Capacitive Reactance:	30913 Ω-kft	9422 Ω-km
		Shunt Capacitive Susceptance:	32.35 µS/kft	9.86 µS/km
Charging Current:			280.1 mA/kft	919.1 mA/km
1-Phase Reactance/Impedance:		Inductive Reactance:	0.022 Ω/kft	0.072 Ω/km

	Real	Imag.	Impedance	Real	Imag.	Impedance
Pos. & Neg. Seq. Impedance (Met. Shield):	0.041	0.022	0.047 Ω/kft	0.135	0.072	0.153 Ω/km
Zero Seq. Impedance (Earth & Met. Shield):	0.332	0.160	0.368 Ω/kft	1.089	0.524	1.208 Ω/km

3-Phase Reactance/Impedance: Inductive Reactance: 0.042 Ω/kft; 0.137 Ω/km

	Real	Imag.	Impedance	Real	Imag.	Impedance
Pos. & Neg. Seq. Impedance (Met. Shield):	0.044	0.041	0.061 Ω/kft	0.145	0.136	0.199 Ω/km
Zero Seq. Impedance (Earth & Met. Shield):	0.159	0.042	0.164 Ω/kft	0.522	0.138	0.540 Ω/km
Zero Seq. Impedance (Earth Only):	0.095	0.729	0.736 Ω/kft	0.313	2.393	2.413 Ω/km
Zero Seq. Impedance (Met. Shield Only):	0.164	0.022	0.165 Ω/kft	0.538	0.072	0.543 Ω/km

Dielectric Losses (Per Phase):		8.33 W/kft	27.32 W/km
Electrical Stress:	Insulation Average:	39.36 V/mil	129.15 kV/mm
	Conductor Shield - Insulation Interface Maximum:	50.59 V/mil	166.00 kV/mm
	Insulation - Insulation Shield Interface Minimum:	31.19 V/mil	102.32 kV/mm
Insulation Resistance:		4202.88 MΩ-kft	1280.98 MΩ-km

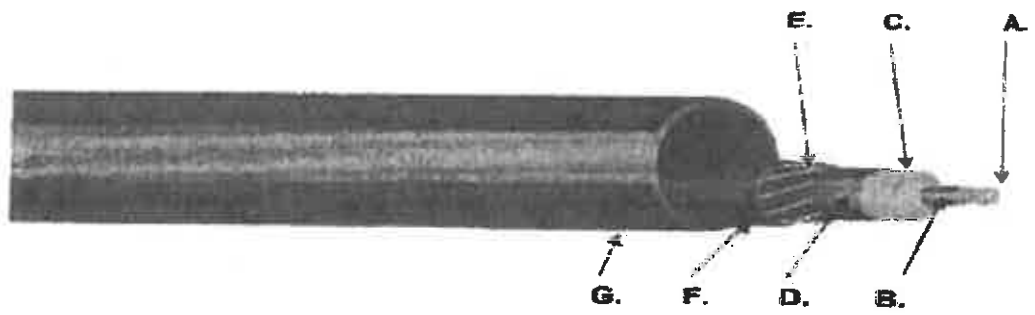
Drawing:	CED # 1111	Cable part #:	NEMA/ICEA Standard: 207432 Rev. 0
Specification Standard:	SECTION 16124 Date: 05/01/09	Prepared by: WEQUNXN	Date: 12/2/2010

General Cable

BICC BRAND

Drawing / Data Sheet

Single Conductor EmPowr® Fill Concentric Neutral (Round Wire) Power Cable 15kV



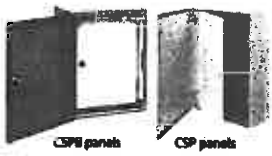
Representative drawing not to scale

Component Description	Thickness (inches) Min.	Nom.*	Max.	Diameter (inches) Min	Nom.*	Max
A: Conductor 4/0 AWG Class B Compressed Strand CU Conductor	--	--	--	0.502	0.512	0.522
B: Conductor Shield Semiconducting Thermoset Polymer	0.012	0.018	--	--	0.548	--
C: Insulation **Insulation Level** Ethylene Propylene Rubber 133%	0.210	0.220	0.250	0.955	0.988	1.045
D: Insulation Shield Semiconducting Thermoset Polymer	0.030	0.035	0.060	1.015	1.058	1.145
E: Concentric Neutral / Metallic Shield 20 x 10 AWG Bare Copper Round Wire	--	--	--	--	1.250	--
F: Jacket Extruded-To-Fill Linear Low Density Polyethylene	0.080	0.091	0.000	--	1.432	--
G: Conduit 2.00" HDPE Conduit	--	--	--	--	--	--
Single Conductor Finished Cable Nominal Weight: 1897 lb/kft *						

* - Nominal Values are Subject to Manufacturing Tolerances; Bold Font Indicates Minimum Average Values

Customer:	CED #1111	Customer P/N:	EA/PG Number: 882466 Rev 0
Specification / Standard:	SECTION 260513.0098 Date: 05/01/09	Prepared By: WYQUNXN	Date: 3/30/2010

Utility Engineering Center
Tel: 859-572-8000



CONCEPT™ Swing-Out Panels

Panels swing clear from the front of the enclosure to provide access to mounted internal equipment. For CSPB panels, maximum swing is 94 degrees. For CSP panels, maximum panel swing is 106 degrees. Distance from panel surface to door when in the latched position is 1.71 in. (43 mm) for solid doors and 1.45 in. (37 mm) for window doors. Kits include panel, brackets and hardware to mount to the front flange. Panel is painted white.

Swing-out panels also can be mounted on front-to-back adjustable rails. CSPB panels require adapter CSPBADB and front-to-back adjustable rails for front-to-back adjustment.

BULLETIN: CWY

07/01/2006

CSPB Panels

Catalog Number	Fits Enclosure Size (in.)	Fits Enclosure Size (mm)	Panel Size (in.)	Panel Size (mm)
CSPB1212	12.00 x 12.00	305 x 305	9.72 x 9.75	247 x 248
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSPB1612	16.00 x 12.00	406 x 305	13.72 x 9.75	349 x 248
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSPB1616	16.00 x 16.00	406 x 406	13.72 x 13.75	349 x 349
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSPB1620	16.00 x 20.00	406 x 508	13.72 x 17.75	349 x 451
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSPB2016	20.00 x 16.00	508 x 406	17.72 x 13.75	450 x 349
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSPB2020	20.00 x 20.00	508 x 508	17.72 x 17.75	450 x 451
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				

Instruction					
CSPB2024	20.00 x 24.00	508 x 610	17.72 x 21.75	450 x 553	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB2416	24.00 x 16.00	610 x 406	21.72 x 13.73	552 x 349	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB2420	24.00 x 20.00	610 x 508	21.72 x 17.75	552.452	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB2424	24.00 x 24.00	610 x 610	21.72 x 21.75	552 x 553	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB2430	24.00 x 30.00	610 x 762	21.72 x 27.75	552 x 705	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB3020	30.00 x 20.00	762 x 508	27.72 x 17.75	704 x 451	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB3024	30.00 x 24.00	762 x 610	27.72 x 21.75	704 x 553	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB3030	30.00 x 30.00	762 x 762	27.72 x 27.75	704 x 705	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB3624	36.00 x 24.00	914 x 610	33.72 x 21.75	857 x 553	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB3630	36.00 x 30.00	914 x 762	33.72 x 27.75	857 x 705	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB3636	36.00 x 36.00	914 x 914	33.72 x 33.75	857 x 857	

More Info
Add To BOM
2D CAD Drawing
3D STEP Drawing
Spec Sheet
Instruction

CSPB4236	42.00 x 36.00	1067 x 914	39.72 x 33.75	1009 x 857
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB4824	48.00 x 24.00	1219 x 610	45.72 x 21.75	1161 x 553	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB4836	48.00 x 36.00	1219 x 914	45.72 x 33.75	1161 x 857	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					
CSPB6036	60.00 x 36.00	1542 x 914	57.72 x 33.75	1466 x 857	
More Info					
Add To BOM					
2D CAD Drawing					
3D STEP Drawing					
Spec Sheet					
Instruction					

CSP Panels

Catalog Number	Fits Enclosure (in.)	Fits Enclosure (mm)	Panel Size (in.)	Panel Size (mm)
CSP1212	12.00 x 12.00	305 x 305	9.78 x 9.84	248 x 250
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSP1612	16.00 x 12.00	406 x 305	13.78 x 9.84	350 x 250
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSP1616	16.00 x 16.00	406 x 406	13.78 x 13.84	350 x 352
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSP1620	16.00 x 20.00	406 x 508	13.78 x 17.84	350 x 453
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				
CSP2016	20.00 x 16.00	508 x 406	17.78 x 13.84	452 x 352
More Info				
Add To BOM				
2D CAD Drawing				

3D STEP Drawing Spec Sheet Instruction **CSP2020** More Info Add To BOM	20.00 x 20.00	508 x 508	17.78 x 17.84	452 x 453
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP2024** More Info Add To BOM	20.00 x 24.00	508 x 610	17.78 x 21.84	452 x 555
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP2416** More Info Add To BOM	24.00 x 16.00	610 x 406	21.78 x 13.84	553 x 352
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP2420** More Info Add To BOM	24.00 x 20.00	610 x 508	21.78 x 17.84	553 x 453
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP2424** More Info Add To BOM	24.00 x 24.00	610 x 610	21.78 x 21.84	553 x 555
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP3020** More Info Add To BOM	30.00 x 20.00	762 x 508	27.78 x 17.84	706 x 453
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP3024** More Info Add To BOM	30.00 x 24.00	762 x 610	27.78 x 21.84	706 x 555
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP3030** More Info Add To BOM	30.00 x 30.00	762 x 762	27.78 x 27.84	706 x 707
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP3624** More Info Add To BOM	36.00 x 24.00	914 x 610	33.78 x 21.84	858 x 555
2D CAD Drawing 3D STEP Drawing Spec Sheet Instruction **CSP3630** More Info Add To BOM	36.00 x 30.00	914 x 762	33.78 x 27.84	858 x 707
2D CAD Drawing 3D STEP Drawing Spec Sheet				

Instruction				
CSP3636	36.00 x 36.00	914 x 914	33.78 x 33.84	858 x 860
More Info				
Add To BOM				
2D CAD Drawing				
3D STEP Drawing				
Spec Sheet				
Instruction				

Return to HVES

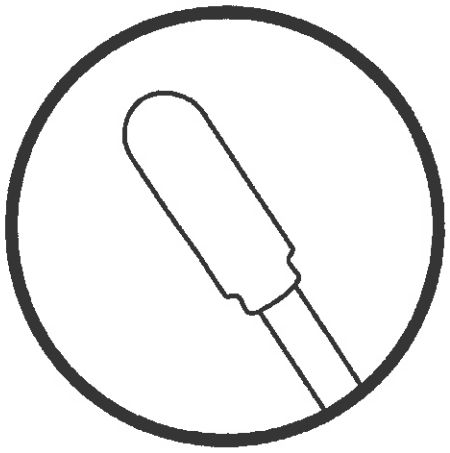
tyco Electronics

Energy Division

Product Installation Instructions

HVES-1520D
15kV Class

1/C Live End Seal for Extruded Dielectric (Poly/EPR) or PILC/VCLC Power Cable



Raychem

Tyco Electronics Corporation
Energy Division
8000 Purfoy Road
Fuquay-Varina, NC 27526

PII-53286, Rev AF
PCN 377750-000
Effective Date: December 18, 2002

General Instructions

Suggested Installation Equipment (not supplied with kit)

- Cable preparation tools
- Tyco Electronics P63 cable preparation kit or cable manufacturer approved solvent
- Clean, lint-free cloths
- Non-conducting abrasive cloth, 120 grit or finer
- Electrician's tape
- Connector(s) and installation tools
- Tyco Electronics recommended torch

Recommended Tyco Electronics Torches

Install heat-shrinkable cable accessories with a "clean burning" torch, i.e., a propane torch that does not deposit conductive contaminants on the product.

Clean burning torches include the Tyco Electronics FH-2629 (uses refillable propane cylinders) and FH-2616A1 (uses disposable cylinder).

Safety Instructions

Warning: When installing electrical power system accessories, failure to follow applicable personal safety requirements and written installation instructions could result in fire or explosion and serious or fatal injuries.

To avoid risk of accidental fire or explosion when using gas torches, always check all connections for leaks before igniting the torch and follow the torch manufacturer's safety instructions.

To minimize any effect of fumes produced during installation, always provide good ventilation of confined work spaces.

As Tyco Electronics has no control over field conditions which influence product installation, it is understood that the user must take this into account and apply his own experience and expertise when installing product.

Adjusting the Torch

Adjust regulator and torch as required to provide an overall 12- inch bushy flame. The FH-2629 will be all blue, the other torches will have a 3- to 4-inch yellow tip. Use the yellow tip for shrinking.

Regulator Pressure

FH-2616A1	Full pressure
FH-2629	15 psig

Cleaning the Cable

Use an approved solvent, such as the one supplied in the P63 Cable Prep Kit, to clean the cable. Be sure to follow the manufacturer's instructions. Failure to follow these instructions could lead to product failure.

Some newer solvents do not evaporate quickly and need to be removed with a clean, lint-free cloth. Failure to do so could change the volume resistivity of the substrate or leave a residue on the surface.

Please follow the manufacturer's instructions carefully.

General Shrinking Instructions

- Apply outer 3- to 4-inch tip of the flame to heat-shrinkable material with a rapid brushing motion.
- Keep flame moving to avoid scorching.
- Unless otherwise instructed, start shrinking tube at center, working flame around all sides of the tube to apply uniform heat.

To determine if a tube has completely recovered, look for the following, especially on the back and underside of the tube:

1. Uniform wall thickness.
2. Conformance to substrate.
3. No flat spots or chill marks.
4. Visible sealant flow if the tube is coated.

Note: When installing multiple tubes, make sure that the surface of the last tube is still warm before positioning and shrinking the next tube. If installed tube has cooled, re-heat the entire surface.

Installation Instructions

1. Product Selection

Check kit selection with cable diameter dimensions in Table 1.

Table 1

Kit	PILC/Poly Nominal Cable Range	PILC Insulation Diameter Range	Poly Insulation Diameter Range
HVES-1521D	#4-4/0	0.60-0.90" *(15-23mm)*	0.65-1.05" *(17-36mm)*
HVES-1522D	250-350	0.85-1.10" *(21-28mm)*	0.90-1.30" *(23-33mm)*
HVES-1523D	500-750	1.05-1.30" *(26-33mm)*	1.10-1.60" *(28-40mm)*
HVES-1524D	750-1000	1.20-1.50" *(30-38mm)*	1.25-1.80" *(32-45mm)*

2. Prepare Cables

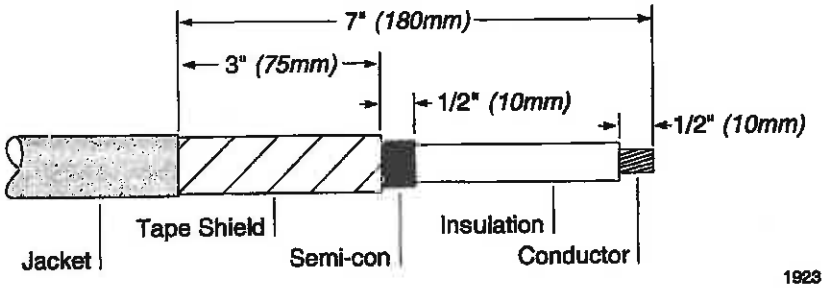
Find the cable type (Choice 1-4) and follow the directions given.

CHOICE 1

Metallic Tape Shield Cable

Prepare the cable as shown.

Go to Step 8, page 5.



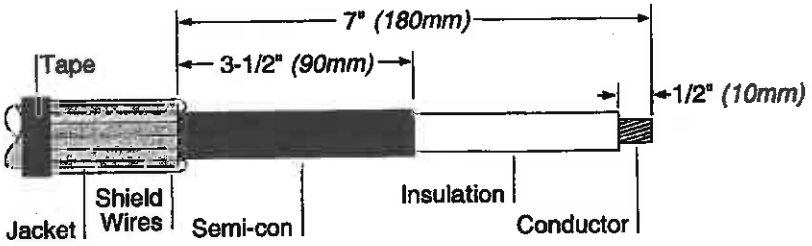
1923

CHOICE 2

Wire Shield Cable

Prepare the cable as shown. Fold the shield wires back over the cable jacket and tape in place as shown.

Go to Step 8, page 5.



1924

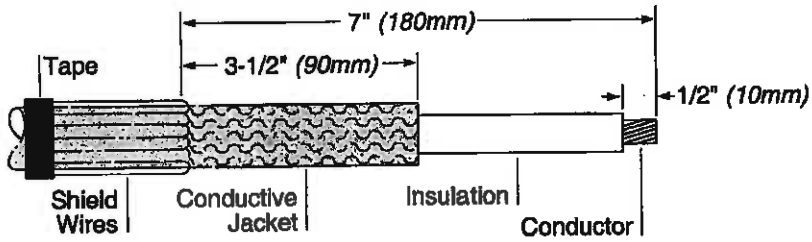
CHOICE 3

UniShield®* Cable

Prepare the cable as shown. Fold the shield wires back over the cable jacket and tape in place as shown.

Go to Step 8, page 5.

*UniShield is a registered trademark of BICC General Cable Industries, INC.



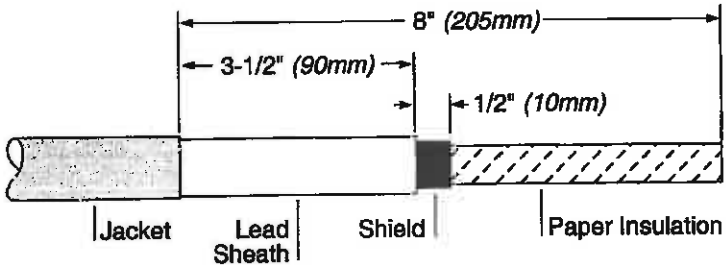
1925

CHOICE 4

PILC Cable

Prepare the cable as shown.

Go to Step 3, page 4.

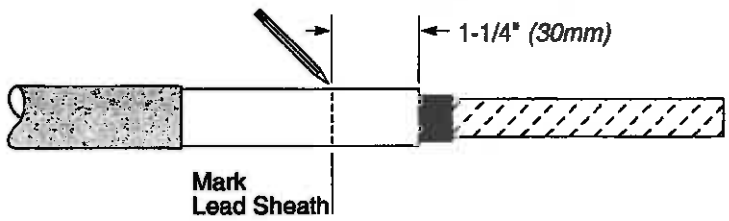


1926

3. Mark lead Sheath

Steps 3-7 apply to PILC cable only.

Mark the lead sheath as shown.



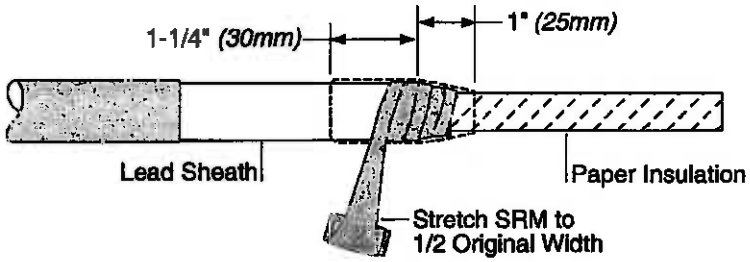
1927

4. Apply Stress Relief Material (SRM) at Lead Sheath Cutback

Remove backing strip from one side of a *long strip* of SRM. Roll up the SRM and remaining backing strip into a convenient size.

Removing the remaining backing strip, tightly wrap SRM around the shield. Continue wrapping to the mark on the lead sheath, then back across the shield onto the paper insulation as shown.

Note: Apply a maximum thickness of 1/8" *(3mm)* of SRM over the lead sheath to prevent excessive diameter build-up. Save the remaining SRM.

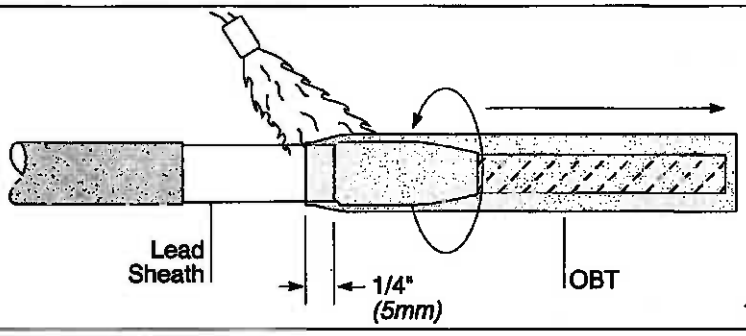


1928

5. Position OBT; Shrink in Place

Place an Oil Barrier Tube (OBT) over the cable 1/4" *(5mm)* from end of SRM as shown. Shrink in place starting at the SRM. Work around the tube with a smooth brushing motion.

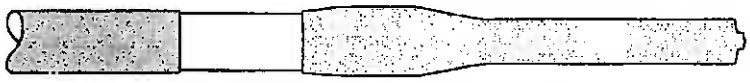
Note: To achieve a smooth, wrinkle-free installation, use a reduced flame to install the thin-walled OBT.



1929

6. Inspect OBTs

The installed OBTs should have a smooth, wrinkle-free surface after shrinking. Reheat to smooth any wrinkled areas.

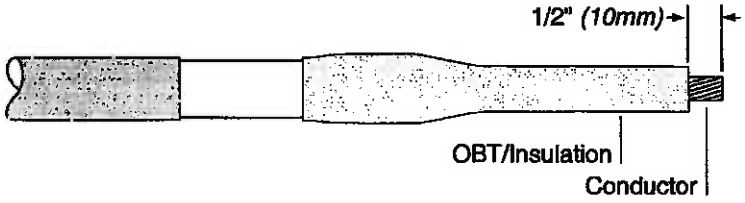


1930

7. Remove Insulation

Remove the OBT/insulation as shown.

Go to Step 9, page 5.



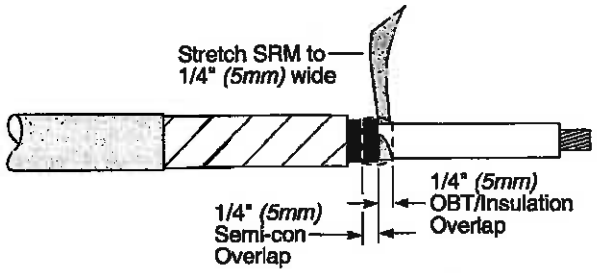
1931

8. Apply SRM at Semi-con Step

Note: Step 8 applies to Poly/EPR cable only.

Remove backings from *short angle-cut piece* of SRM. Place tip of SRM at semi-con cutback and tightly wrap to fill semi-con step. Overlap insulation and semi-con as shown. Taper SRM down to meet insulation.

Note: If using UniShield cable, apply SRM as shown to fill conductive jacket step.



1932

9. Install End Seal Plug

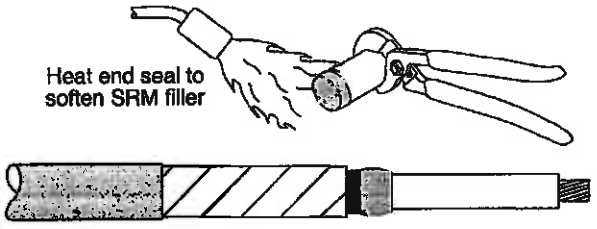
Note: A metallic tape shield cable is shown as an example in the following steps. Instructions apply to all cable types previously mentioned unless otherwise stated.

Note: Do Not apply heat directly to yellow mastic.

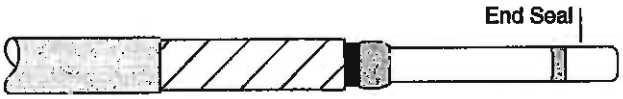
Pick up the tube at the mastic end with a pair of pliers and heat the closed section. Do not apply flame to yellow mastic directly. Set plug aside for 1-2 minutes to allow heat to penetrate and soften yellow SRM filler.

While the plug is absorbing the heat, heat the exposed conductor. A hot conductor will make plug installation easier.

Twist the plug onto the conductor until the SRM filler extrudes to meet or exceed the cable insulation diameter.



1933

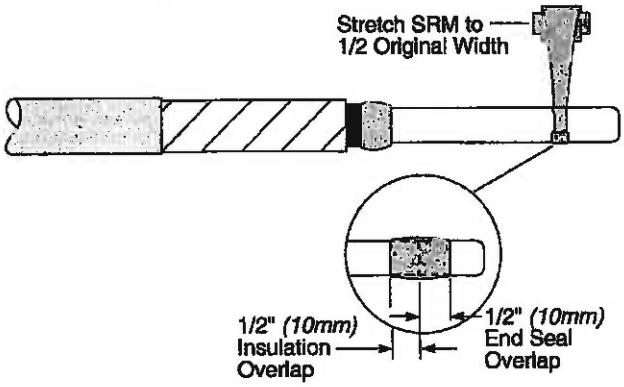


1934

10. Apply SRM

Remove backing strip from one side of a *long strip* of SRM. Roll up the SRM and remaining backing strip into a convenient size.

Removing the remaining backing strip, tightly wrap one, half-lapped layer of SRM around insulation and end seal plug as shown.



1935

11. Install Ground

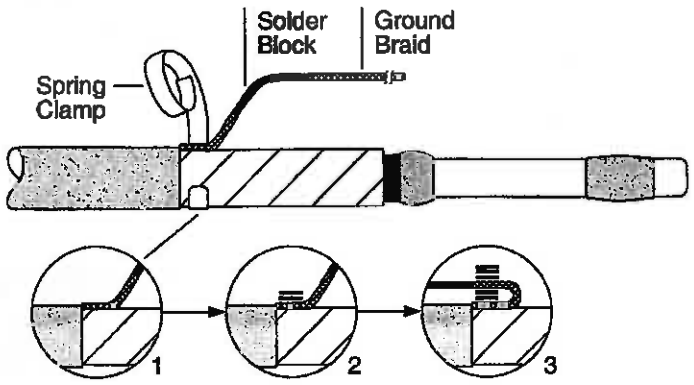
Choose the appropriate cable type (Choice 1-3) and follow the directions given.

CHOICE 1

Metallic Tape Shield Cable

(1) Flare one end of the ground braid and place it onto the metallic tape, butted up to the jacket cutback. (2) Attach the braid to the shield by placing two wraps of the spring clamp over the braid. (3) Fold the braid back over the spring clamp wraps. Continue to wrap the remaining clamp over the braid. Tighten clamp by twisting it in the direction it is wrapped and secure with copper foil tape provided.

Go to Step 12, page 7.



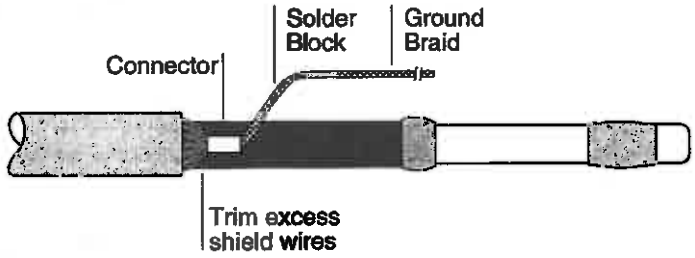
1936

CHOICE 2

Wire Shield or UniShield Cable

Pigtail the shield wires and crimp on to the ground braid using the connector provided. Position the connector so the solder blocked portion of ground braid is aligned with the jacket cutback (or equivalent position). Trim excess shield wires.

Go to Step 12, page 7.



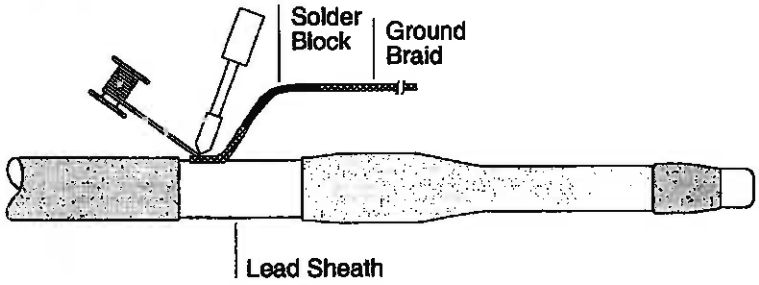
1937

CHOICE 3

PILC Cable

Align the solder blocked section of ground braid over the jacket cutback. Solder ground braid onto lead sheath. Deburr connection.

Go to Step 12, page 7.

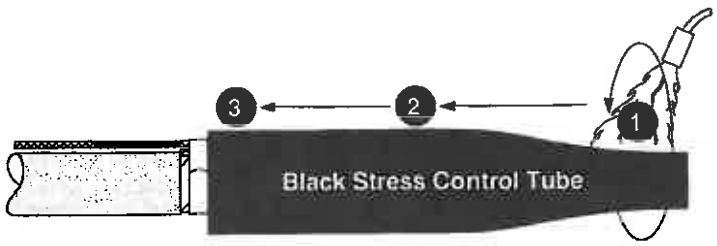


1938

12. Position Black Stress Control Tube; Shrink in Place

Place the black stress control tube over the cable and align with the end of the end seal as shown.

Begin shrinking from the end as shown, working the torch with a smooth brushing motion around all sides of the tube. As the end shrinks, work the torch as before toward the jacket end.



1939

13. Position Red Insulating Tube; Shrink in Place

Place the red insulating tube over the cable and align with the end of the Black Stress Control Tube as shown.

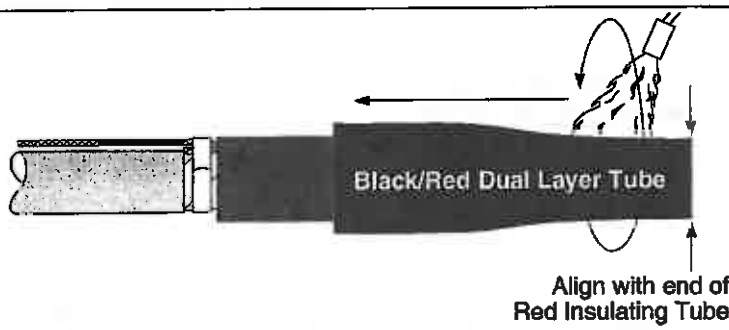
Shrink in place using method described in Step 12.

1940

14. Position Black/Red Dual Layer Tubes; Shrink in Place

Place the black/red dual layer tube over the cable and align with the end of the Red Insulating Tube as shown.

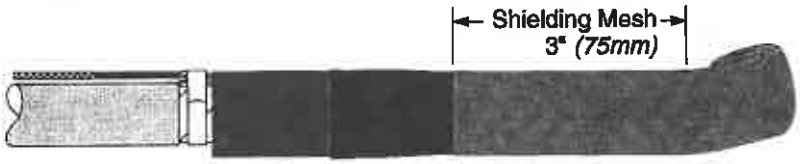
Shrink in place using method described in Step 12.



1941

15. Apply Shielding Mesh

Open the end of the shielding mesh and slide it over the end of the conductor for 3" *(75mm)* as shown.



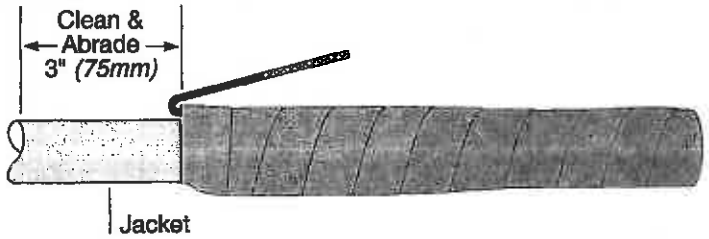
1941a

Halflap the mesh over the installed tube as shown. Cut excess braid and tie off. (Mesh may be solder tacked to metallic shield or lead sheath.)

1942

16. Abrade & Clean Cable Jacket

Abrade and clean the cable jacket (or lead sheath if unjacketed PILC cable) for 3" *(175mm)* from the jacket cutback or equivalent position.

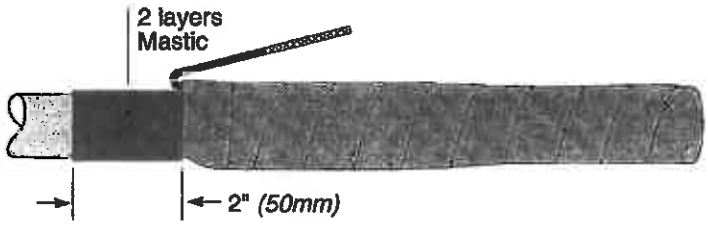


1943

17. Apply Mastic Under Braid

Lay the ground braid back across the installed shielding mesh.

Wrap two layers of mastic beginning 2" *(50mm)* onto the cable jacket and extending to installed ground braid.



1944

18. Apply Mastic Over Braid

Lay the ground braid back across the cable jacket and press into the installed mastic.

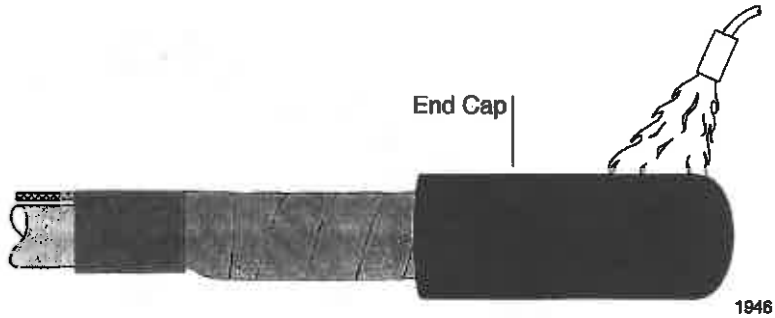
Wrap two additional layers of mastic directly over the braid and the mastic installed in Step 17.

1945

19. Position End Cap; Shrink in Place

Place the end cap over the shielding mesh as far as possible. Begin shrinking at the closed end, working the torch with a smooth brushing motion around all sides of the cap.

Continue to the open end as the cap shrinks and conforms to the cable contours.

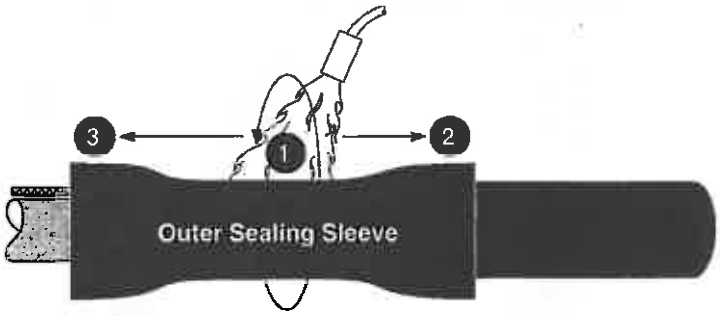


1946

20. Position Outer Sealing Sleeve; Shrink in Place

Place the tube over the end cap and center to overlap the end cap and red sealant over the ground braids.

Begin shrinking in the center of the tube, working the torch with a smooth brushing motion around all sides of the tube. After the center has shrunk, continue as before toward the cap end, then to the jacket end.



1947

Allow to cool enough to touch before moving or placing in service.

Installation is complete.

1948

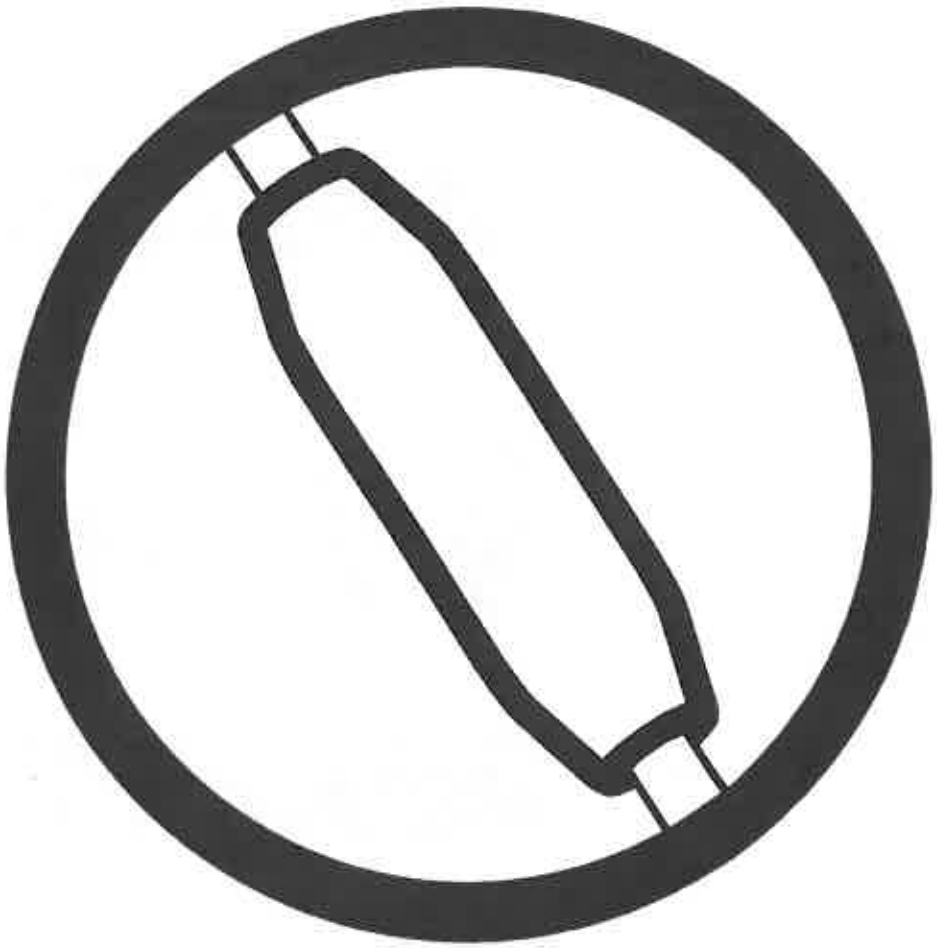
Raychem

Product Installation Instructions

HVS-1510S-J Series
15kV Class

Splice for 1/C Jacketed Concentric Neutral Power Cables

2 tube splice
Existing



Raychem Corporation
Electrical Products
8000 Purfoy Road
Fuquay-Varina, NC 27526

PII-54728, Rev AC
DCR C58811
PCN 266983-000
Effective Date: July 27, 1998

General Instructions

Suggested Installation Equipment (not supplied with kit)

- Cable preparation tools
- Raychem P42 cable preparation kit or cable manufacturer approved solvent
- Clean, lint-free cloths
- Non-conducting abrasive cloth, 120 grit or finer
- Electrician's tape
- Connector(s) and installation tools
- Raychem recommended torch

Recommended Raychem Torches

Install heat-shrinkable cable accessories with a "clean burning" torch, i.e., a propane torch that does not deposit conductive contaminants on the product.

Clean burning torches include the Raychem FH-2609, FH-2629 (uses refillable propane cylinders) and FH-2616A1 (uses disposable cylinder).

Safety Instructions

Warning: When installing electrical power system accessories, failure to follow applicable personal safety requirements and written installation instructions could result in fire or explosion and serious or fatal injuries.

To avoid risk of accidental fire or explosion when using gas torches, always check all connections for leaks before igniting the torch and follow the torch manufacturer's safety instructions.

To minimize any effect of fumes produced during installation, always provide good ventilation of confined work spaces.

Adjusting the Torch

Adjust regulator and torch as required to provide an overall 12-inch bushy flame. The FH-2629 will be all blue, the other torches will have a 3- to 4-inch yellow tip. Use the yellow tip for shrinking.

Regulator Pressure

FH-2616A1	Full pressure
FH-2609	5 psig
FH-2629	15 psig

General Shrinking Instructions

- Apply outer 3- to 4-inch tip of the flame to heat-shrinkable material with a rapid brushing motion.
- Keep flame moving to avoid scorching.
- Unless otherwise instructed, start shrinking tube at center, working flame around all sides of the tube to apply uniform heat.

To determine if a tube has completely recovered, look for the following, especially on the back and underside of the tube:

1. Uniform wall thickness.
2. Conformance to substrate.
3. No flat spots or chill marks.
4. Visible sealant flow if the tube is coated.

Note: When installing multiple tubes, make sure that the surface of the last tube is still warm before positioning and shrinking the next tube. If installed tube has cooled, re-heat the entire surface.

Installation Instructions

1. Product selection.

Check kit selection with cable diameter dimensions in Table 1.

Table 1

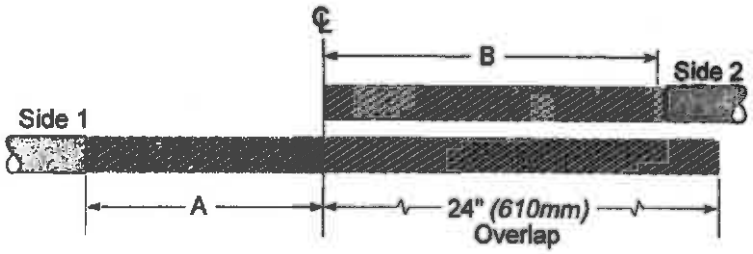
Kit	Nominal Cable Range	Insulation Diameter Range	Maximum Jacket Diameter	Maximum Connector Dimensions	
				Length	Diameter
HVS-1511-SJ	#2-2/0 AWG	0.65-0.95" *(17-24mm)*	1.30" *(33mm)*	4.00" *(100mm)*	0.75" *(19mm)*
HVS-1512-SJ	4/0-400 kcmil	0.85-1.30" *(22-33mm)*	1.65" *(42mm)*	5.50" *(140mm)*	1.25" *(32mm)*
HVS-1513-SJ	500-600 kcmil	1.10-1.50" *(28-38mm)*	1.90" *(48mm)*	6.00" *(152mm)*	1.45" *(37mm)*
HVS-1514-SJ	750-1000 kcmil	1.30-1.90" *(33-48mm)*	2.30" *(58mm)*	8.00" *(203mm)*	1.85" *(47mm)*

Table 2

Kit	Jacket Cutback A	Jacket Cutback B	Semi-con Cutback C	Neutral Wire Cut D	Maximum Connector Dimensions Length	Maximum Connector Dimensions Diameter	Expansion Gap "X"
Dimensions in inches							
HVS-1511-SJ	8"	12"	4.50"	4.00"	4.00"	0.75"	0.25"
HVS-1512-SJ	9"	13"	5.25"	4.00"	5.50"	1.25"	0.25"
HVS-1513-SJ	10"	15"	5.75"	5.00"	6.00"	1.45"	0.50"
HVS-1514-SJ	11"	17"	6.75"	6.00"	8.00"	1.85"	0.50"
Dimensions in millimeters							
HVS-1511-SJ	*203mm*	*305mm*	*114mm*	*102mm*	*100mm*	*19mm*	*6mm*
HVS-1512-SJ	*229mm*	*330mm*	*133mm*	*102mm*	*140mm*	*32mm*	*6mm*
HVS-1513-SJ	*254mm*	*381mm*	*146mm*	*127mm*	*152mm*	*37mm*	*13mm*
HVS-1514-SJ	*279mm*	*432mm*	*171mm*	*152mm*	*203mm*	*47mm*	*13mm*

2. Prepare cables.

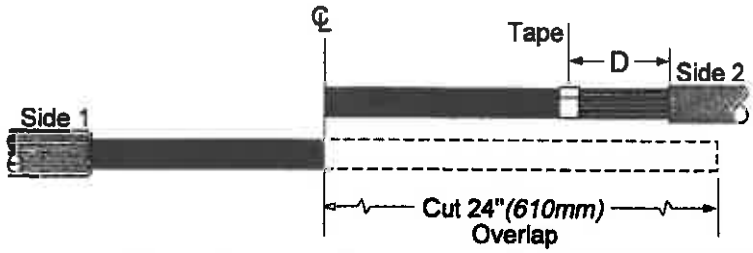
Overlap the two cables as shown. Refer to Table 2 and remove the cable jacket to Dimensions A (plus the 24" overlap) and B.



1213

Fold back the neutral wires on Side 1. Trim the neutral wires on Side 2 to Dimension D and tape over ends as shown.

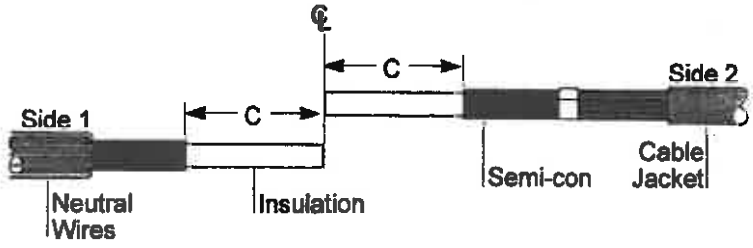
Cut Side 1 cable at center line.



1214

3. Remove semi-con.

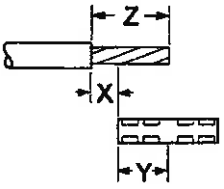
Refer to Table 2 and remove the semi-con to Dimension C.



1215

4. Remove insulation.

Refer to Table 2 and cutback the insulation as shown.

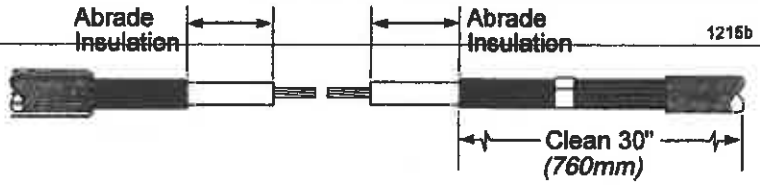


"Z" Insulation Cutback = "X" Expansion Gap + "Y" 1/2 Length of Connector

400

5. Abrade insulation; clean cable.

Abrade the insulation, if necessary, to remove imbedded semi-con. Clean cable as shown.

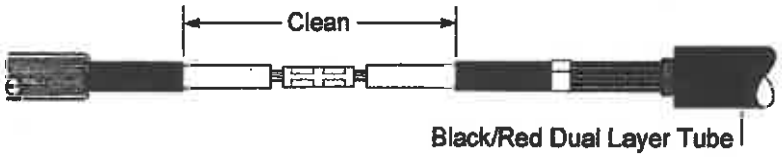


6. Place Black/Red Dual Layer tube over cable; install connector.

Protect tube from end of conductor as it is placed over the cable.

Install the connector. After installation, deburr connector.

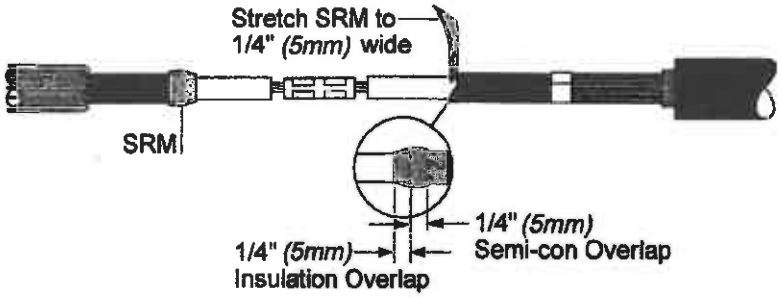
Using an approved solvent, clean the insulation as shown.



7. Apply SRM at semi-con cutback.

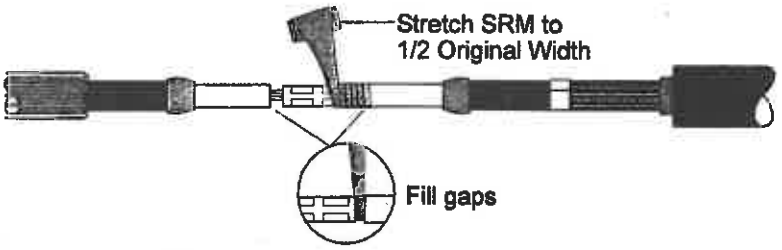
Remove backings from the *short angle-cut piece* of SRM. Place tip of SRM at semi-con cutback and tightly wrap to fill semi-con step. Overlap semi-con and insulation as shown. Taper SRM down to meet insulation.

Depending on cable size, more SRM may be supplied than is required to fill the step. After filling the step, discard excess *angle-cut pieces.*



8. Apply SRM over connector.

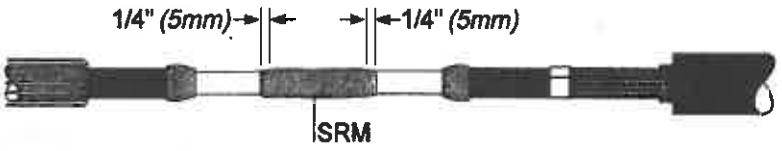
Remove backing from one side of the *long strip* of Stress Relief Material (SRM). Roll the SRM and remaining backing strip into a convenient size. Removing the remaining backing strip, tightly wrap the SRM around the connector and exposed conductor. **Be sure to fill the gaps and low spots around the connector.**



Continue to wrap SRM 1/4" (5mm) onto the solvent cleaned insulation as shown. (Finished SRM diameter should be only slightly larger than that of the cable insulation). It may not be necessary to use all of the SRM.

On cables of differing insulation diameters, SRM should be tapered down from the larger insulation OD to the smaller.

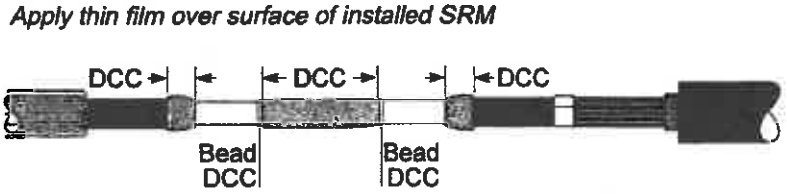
Note: If connector diameter is larger than insulation diameter, apply two tightly wrapped, half-lapped layers of SRM over the entire connector. Discard any excess SRM *(long strips).*



9. Apply Discharge Control Compound (DCC).

Snip open end of the DCC ampule and apply a thin film of compound over the three applications of SRM.

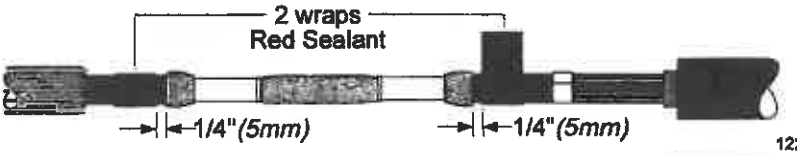
Apply a bead of DCC around the circumference of the SRM edge on each side of the connector.



1220

10. Apply red sealant.

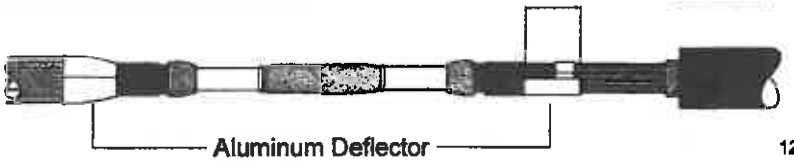
Remove release paper from red sealant strip and place two full wraps onto the cable semi-con layer 1/4" *(5mm)* from previously applied SRM.



1221

11. Apply aluminum deflector.

Remove backing and install the aluminum deflector around the cable semi-con layer butted up to the edge of the red sealant applied in Step 10.



1222

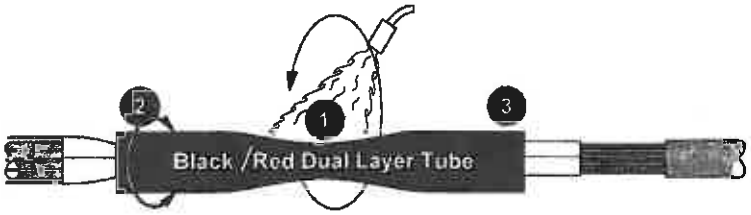
12. Position black/red dual layer tube; shrink in place.

Center tube over joint as shown. Begin shrinking at center of tube (1), working torch with a smooth brushing motion around the tube. Before moving away from the center, make sure the tube has shrunk by gently twisting the unshrunk end to feel for resistance. After center portion shrinks, work torch as before toward one end (2), then to the opposite end (3).

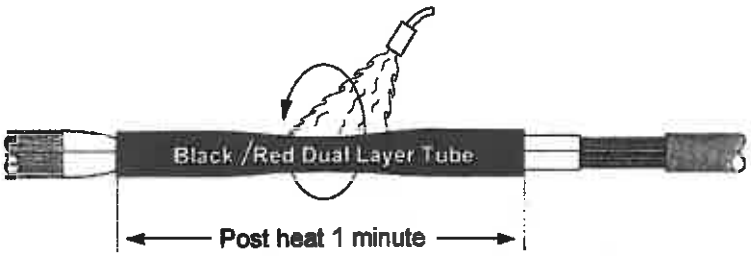
Note: Pay particular attention to the hard to reach parts, especially the back and underside of the tube. The tube should have a smooth and even surface when finished.

Post heat the entire tube for 1 minute after fully shrunk.

After shrinking, remove deflector to allow access to neutral wires.



Twist gently to check for resistance in center.

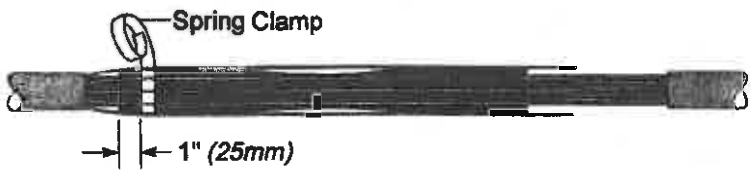


1223

13. Lay out neutral wires; clamp in place as shown.

Place one wrap of spring clamp around the black/red dual layer tube as shown.

Neatly lay all neutral wires (spaced evenly) over spring clamp. Wrap remainder of spring clamp over wires and bind in place with electricians tape.



1224

Installation Instructions

14. Connect neutral wires.

Twist neutral wires together and splice with suitable connector(s). Bind wires to splice.

1225

15. Clean cable jackets.

Abrade and solvent clean cable jackets as shown to provide an oil-free surface.

1225a

16. Position wraparound sleeve.

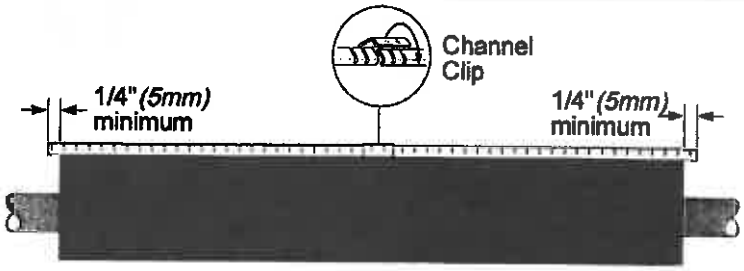
Remove or tape over all sharp points to prevent puncture of wraparound sleeve. Remove backing from the wraparound sealing sleeve and center sleeve over splice. Slide metal channels onto the butted rails.

1227

17. Install channel clip.

If two channels are used, connect the channels with the short channel retention clip. Use pliers to install clip.

Note: Channel(s) must extend beyond the sleeve edge as shown.

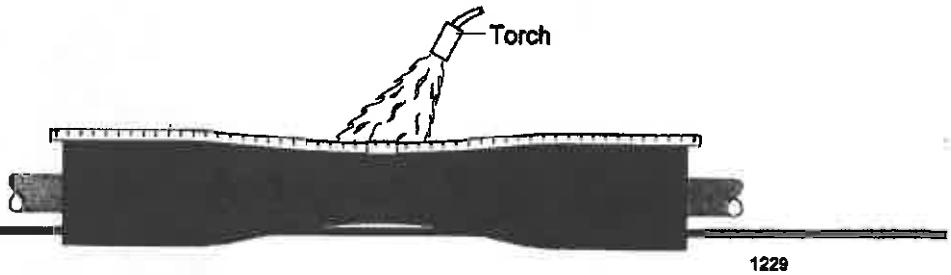


1228

18. Shrink the wraparound sleeve.

Begin shrinking at center and work toward each end.

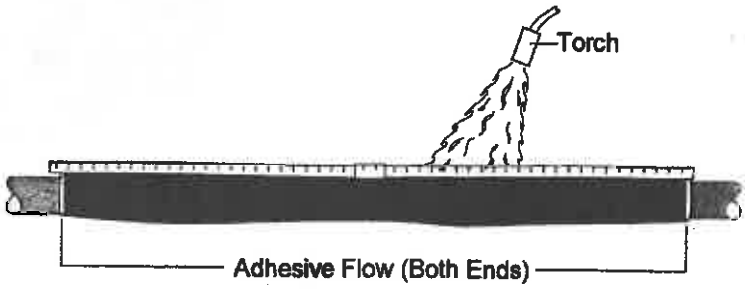
Post heat the entire sleeve (concentrating on metal channel area) for 30 seconds after completely shrunk.



1229

This completes the installation.

Allow splice to cool before moving or placing in service.



1230

COOPER Power Systems

Sectionalizing Equipment

Electrical Apparatus

SecTER™ Cabinet

1000-05

GENERAL

The versatile single- and three-phase SecTER™ sectionalizing terminals from Cooper Power Systems are designed as cable sectionalizing centers, or as permanent or temporary transformer pad covers.

The aesthetic low profile design provides unobtrusive installations for sectionalizing, tapping or terminating underground cable.

The top hinged diagonally cut removable cover and cabinet are designed for easy one man opening and improved access to interior terminations. A door stop prevents the door from accidentally closing.

All cover-to-cabinet seams are designed to exeed ANSI® tamperproof standards. TGIC powder coating exceeds ANSI® coating requirements.

Twelve and fourteen gauge mild steel designs are available. For highly corrosive environments, stainless steel or aluminum are also available. Continuous seam welding ensures a sturdy smooth cabinet.

Universal mounting plates accept 200 amp or 600 amp, two-, three-, or four-position junctions with u-straps. Standard SecTER designs are available in a variety of sizes to suit typical applications and can also be ordered with junctions factory installed.

Optional Features

- Extra cover lifting handles
- 200 or 600 A junctions
- Fiber glass ground sleeves
- Hold down cleats
- Light color mounting plates
- Angled mounting plates
- Extra parking stands

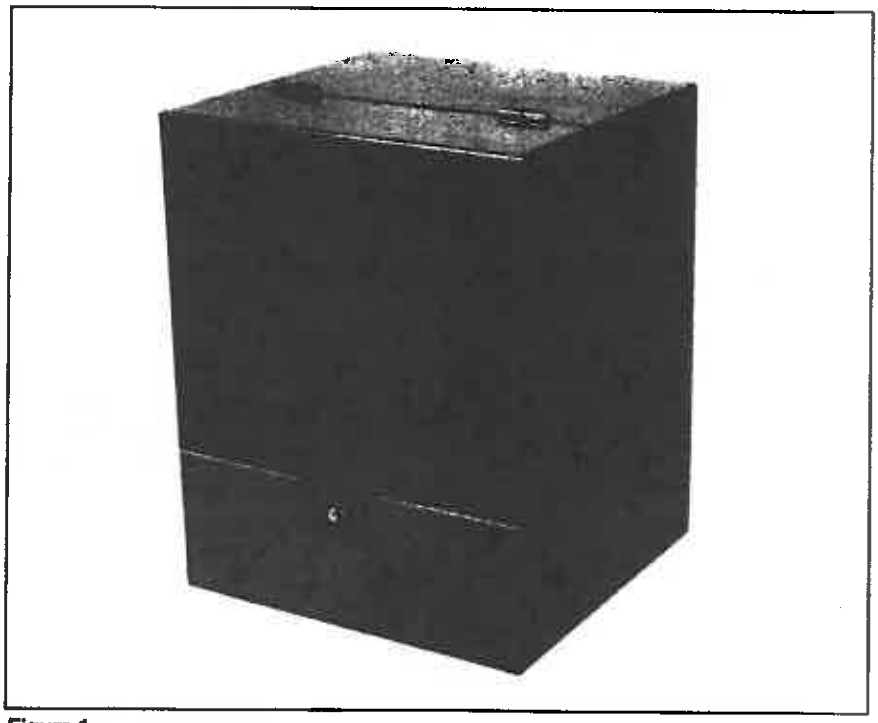


Figure 1.
Series I Single-Phase SecTER Cabinet.

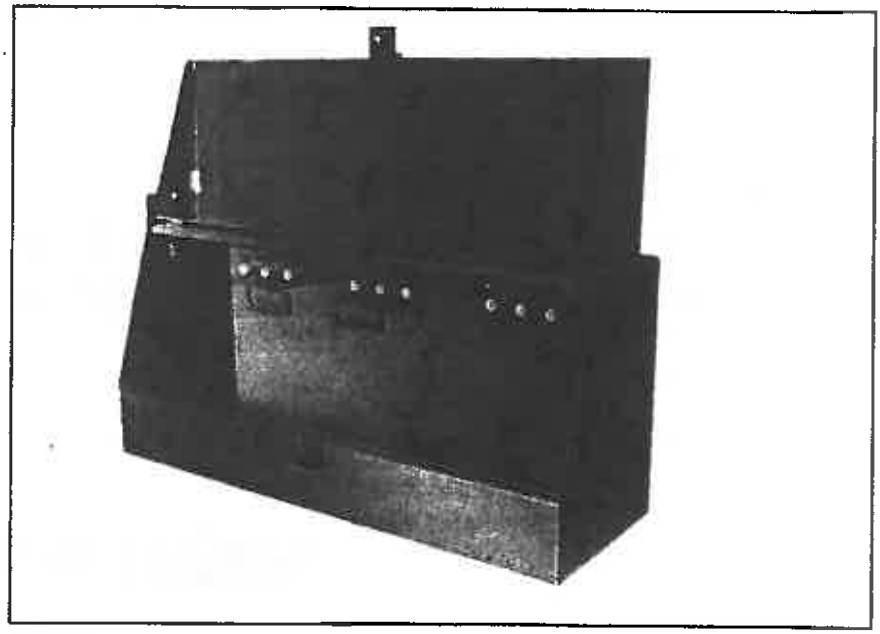


Figure 2.
Series II Three-Phase SecTER Cabinet.

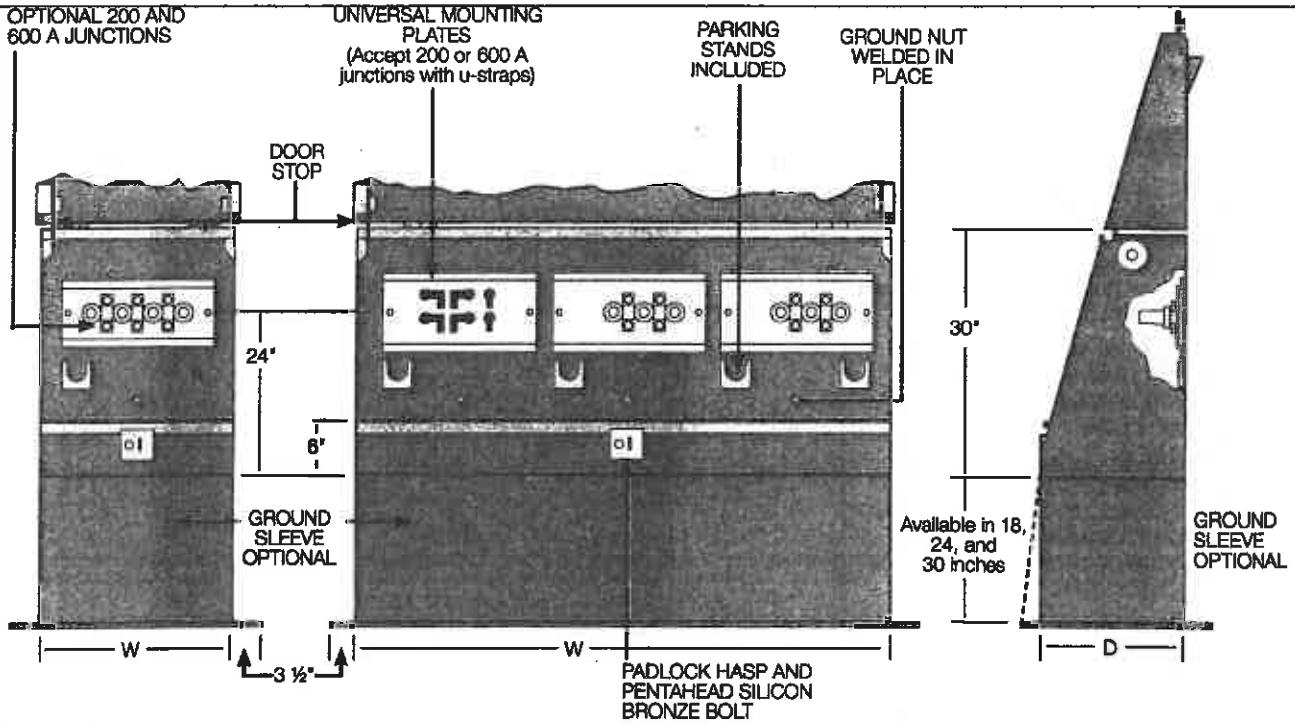


Figure 3.
Series I, standard design with Loadbreak Junction.

NOTE: Dimensions given are for reference only. *Stainless Steel or Aluminum optional.

ORDERING INFORMATION

TABLE 1
Series I

kV Class	Dimensions (in.) H	W	D	Phase	Catalog Number*
Series I[a]					
15/25/35	30	24	22	1	00400L00K54A
15/25/35	30	30	22	1	00400L00K58A
15/25/35	30	36	22	1	00400L00K62A
15/25/35	30	48	22	3	00450L00K02A
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15/25/35	30	84	22	3	00450L00K10A

NOTE:
a = Single-phase units accommodate four-point junctions
Three-phase 48-inch units accommodate a maximum of three three-point junctions
Three-phase 66-inch units accommodate a maximum of three four-point junctions at 15/25 kV
Three-phase 84-inch units accommodate four-point junctions with three vertical feedthrus at 35 kV
22-inch depth allows 600 A junctions and Ts to be installed and operated

* For stainless, change "A" to "S". For aluminum, change "A" to "L".

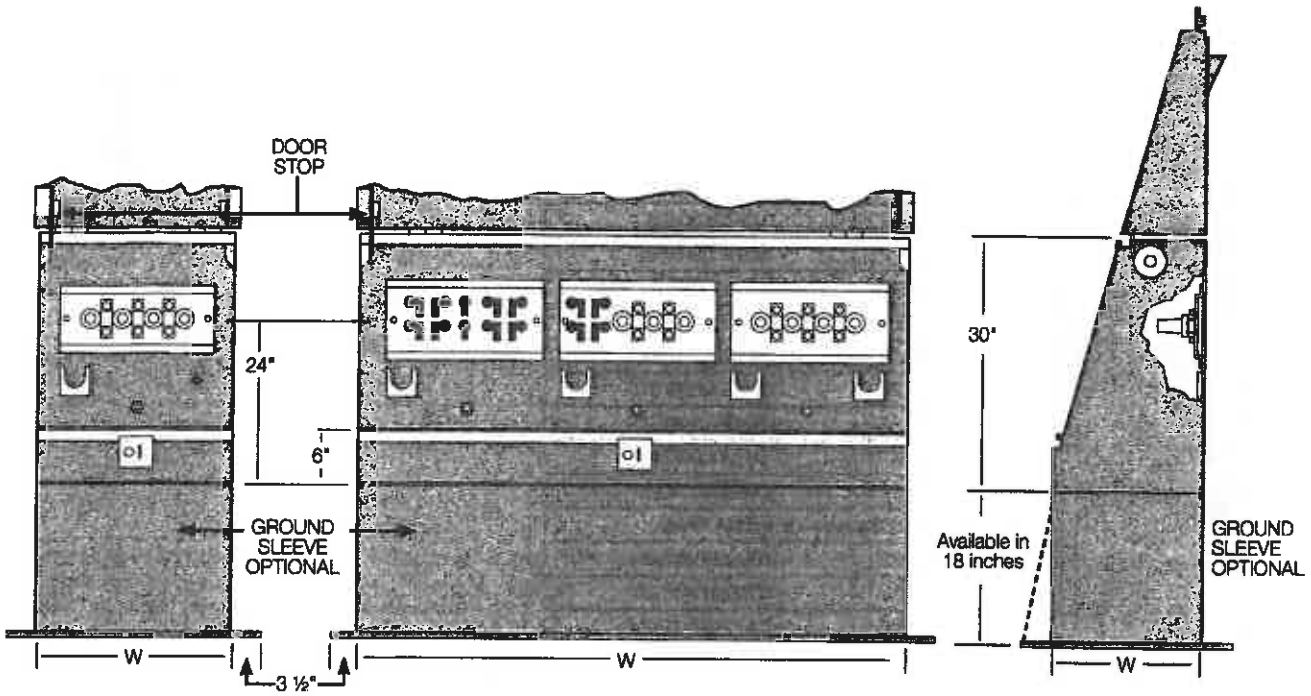


Figure 4.
Series II, standard design with Loadbreak Junction.

NOTE: Dimensions given are for reference only. *Stainless Steel or Aluminum optional.

ORDERING INFORMATION

TABLE 2
Series II[a]

kV Class	Dimensions (in.) H	W	D	Phase	Catalog Number*
Series II*					
15	30	24	15	1	00400L00K72A
15	30	48	15	3	00450L00K28A
15	30	60	15	3	00450L00K30A
15/25	30	30	18	1	00400L00K73A
15/25	30	48	18	3	00450L00K29A
15/25	30	60	18	3	00450L00K31A

NOTE:
a = Single-phase units accommodate four-point junctions
Three-phase 48-inch units accommodate a maximum of three three-point junctions
Three-phase 60-inch units accommodate a maximum of three four-point junctions

* For stainless, change "A" to "S". For aluminum, change "A" to "L".

TABLE 3
Ground Sleeve Information

Type	Dimensions (in.) H	W	D	Catalog Number*
Series I	Ground Sleeves—Fiberglass (18" High)			
	18	24	22	00400L00K02G
	18	30	22	00400L00K03G
	18	36	22	00400L00K04G
	18	48	22	00450L00K04G
	18	66	22	00450L00K05G
	18	84	22	00450L00K06G
	Ground Sleeves—Fiberglass (30 " High)			
	30	24	22	00400L00K05G
	30	30	22	00400L00K06G
	30	36	22	00400L00K07G
	30	48	22	00450L00K07G
	30	66	22	00450L00K08G
	30	84	22	00450L00K09G
	Ground Sleeves—Steel (24 " High)			
	24	24	22	0400L00K10GM
	24	30	22	0400L00K11GM
	24	36	22	0400L00K12GM
	24	48	22	0450L00K17GM
	24	66	22	0450L00K18GM
	24	84	22	0450L00K19GM
Series II	Ground Sleeves—Fiberglass (18 " High)			
	18	24	15	00400L00K00G
	18	48	15	00450L00K00G
	18	60	15	00450L00K02G
	18	30	18	00400L00K01G
	18	48	18	00450L00K01G
	18	60	18	00450L00K03G
	Ground Sleeves—Steel (18 " High)			
	18	24	15	0400L00K13GM
	18	48	15	0450L00K20GM
	18	60	15	0450L00K21GM
	18	30	18	0400L00K14GM
	18	48	18	0450L00K22GM
	18	60	18	0450L00K23GM
	Ground Sleeves—Steel (24 " High)			
	24	60	15	0450L00K25GM
	24	30	18	0400L00K16GM
	24	48	18	0450L00K26GM
	24	60	18	0450L00K27GM

* Width and depth dimensions must be matched to corresponding SecTER dimensions.

COOPER Power Systems

2300 Badger Drive
Waukesha, WI 53188

SEL-751A Feeder Protection Relay

Major Features and Benefits

The SEL-751A Feeder Protection Relay provides an exceptional combination of protection, monitoring, control, and communication in an industrial package.

- **Standard Protection Features**. Protect lines and equipment with phase, negative-sequence, residual-ground, and neutral-ground overcurrent elements. Implement load shedding and other control schemes with current-based over- and underfrequency and breaker failure protection for one three-pole breaker.
- **Optional Arc-Flash Protection**. Use the SEL-751A with optional four-channel fiber-optic arc-flash detector inputs and protection elements. Settable arc-flash phase and neutral overcurrent elements combined with arc-flash light detection elements provide secure, reliable, and fast acting arc-flash event protection.
- **Optional Protection Features**. Use the SEL-751A with one of the voltage input options to provide over- and underfrequency, rate-of-change of frequency, fast rate-of-change of frequency (for Aurora vulnerability mitigation), measured residual current input CT, over- and undervoltage, synchronism-check, dc station battery monitor, arc-flash, power elements, and demand metering elements.
- **Operator Controls and Reclosing**. Easy tripping and closing of the breaker with four programmable front-panel pushbuttons. Implement remote and local control functions, and selectively reclose with synchronism and voltage checks (optional).
- **Relay and Logic Settings Software**. ACSELERATOR QuickSet® SEL-5030 Software reduces engineering costs for relay settings and logic programming. Tools in ACSELERATOR QuickSet make it easy to develop SELOGIC® control equations.
- **Metering and Monitoring**. Use built-in metering functions to eliminate separately mounted metering devices. Analyze Sequential Events Recorder (SER) reports and oscillographic event reports for rapid commissioning, testing, and post-fault diagnostics. Unsolicited SER protocol allows station-wide collection of binary SER messages. The arc-flash detection option provides light metering and event reports for commissioning and arc-flash event capture for analysis.
- **Wye or Delta Voltage Inputs**. Optional voltage inputs allow for either wye-connected, open-delta-connected, or single voltage inputs to the relay.
- **Additional Standard Features**. The SEL-751A also includes Modbus® RTU, Event Messenger support, MIRRORED BITS® communications, load profile, breaker wear monitoring, support for 12 external RTDs (SEL-2600), IRIG-B input, advanced SELOGIC, and IEEE C37.118-compliant synchrophasor protocol.
- **Optional Features**. Select from a wide offering of optional features, including IEC 61850, DNP3 serial and LAN/WAN, Modbus TCP/IP, Simple Network Time Protocol (SNTP), 10 internal RTDs, expanded digital/analog I/O, voltage inputs, arc-flash fiber-optic inputs, additional EIA-232 or EIA-485 communication ports, fiber-optic serial port, single or dual, copper-wire or fiber-optic Ethernet ports, and configurable labels.

Overview

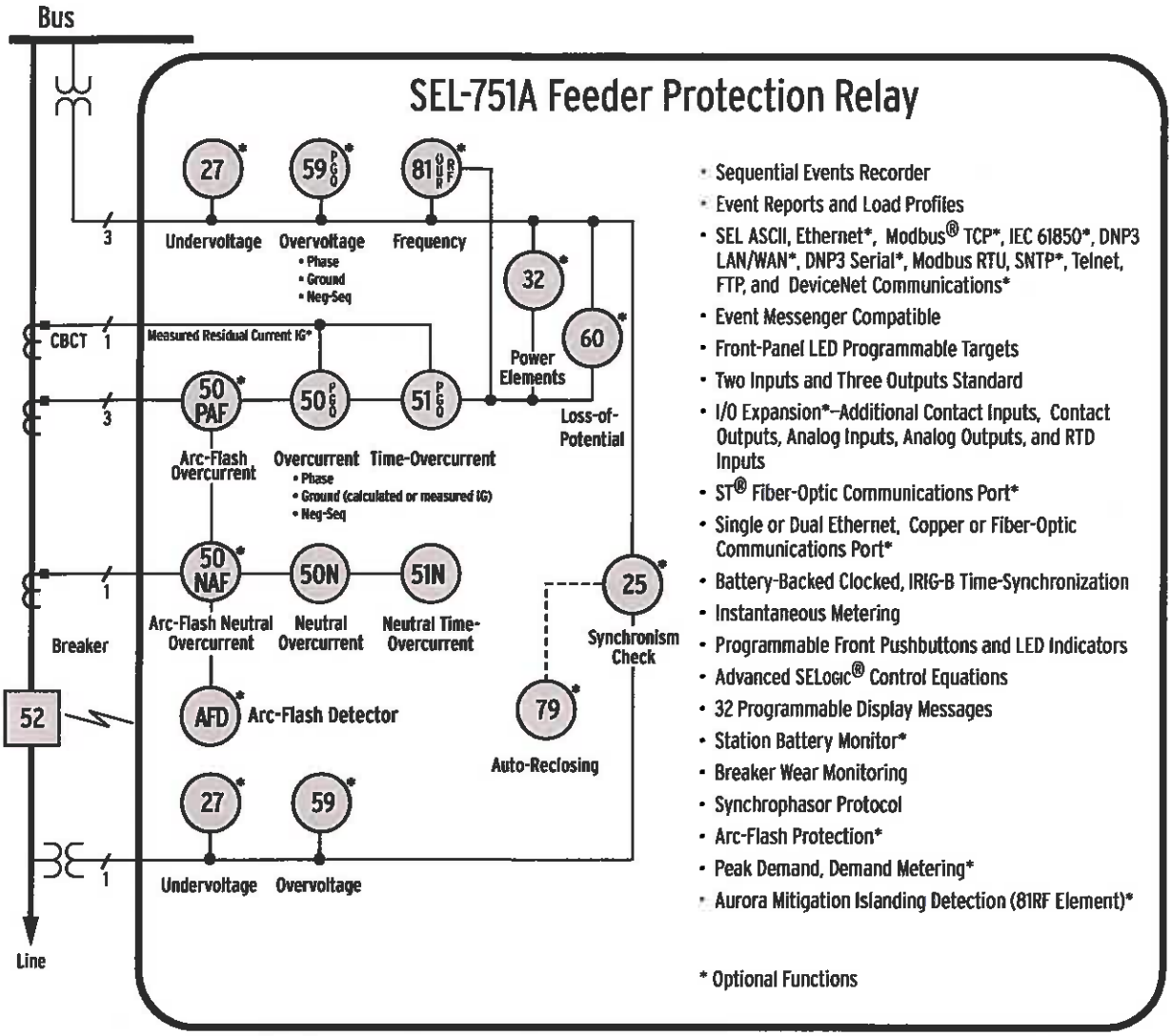


Figure 1 Functional Diagram

Protection Features

The SEL-751A includes a robust set of phase, negative-sequence, residual, and neutral overcurrent elements. Each element type has four levels of instantaneous protection. Each element type has two time-overcurrent elements (except negative-sequence, which has one time-overcurrent element). *Table 1* lists the curves available in the SEL-751A.

The SEL-751A has two reset characteristic choices for each time-overcurrent element. One choice resets the elements if current drops below pickup for at least one cycle. The other choice emulates electromechanical induction disc elements, where the reset time depends on the time dial setting, the percentage of disc travel, and the amount of current.

Table 1 Time-Overcurrent Curves

US	IEC
Moderately Inverse	Standard Inverse
Inverse	Very Inverse
Very Inverse	Extremely Inverse
Extremely Inverse	Long-Time Inverse
Short-Time Inverse	Short-Time Inverse

Overcurrent Elements for Phase Fault Detection

Phase and negative-sequence overcurrent elements detect phase faults. Negative-sequence current elements ignore three-phase load to provide more sensitive coverage of phase-to-phase faults. Phase overcurrent elements detect three-phase faults, which do not have significant negative-sequence quantities.

Overcurrent Elements for Ground Fault Detection

Calculated residual current or optional measured residual current (IG), neutral (IN), and negative-sequence overcurrent elements detect ground faults. In addition to the 1 A/5 A neutral CT, the SEL-751A offers optional high-sensitive neutral element with 50 mA or 2.5 mA nominal current rating.

Wye or Open-Delta Voltages

Wye-connected (four-wire) voltage or open-delta-connected (three-wire) voltage can be applied to three-phase voltage inputs VA, VB, VC, and N, as shown in *Figure 2*. You only need to make a global setting (DELTA_Y = wye or DELTA_Y = delta) and an external wiring change—no internal relay hardware changes or adjustments are required. Thus, a single SEL-751A model meets all your distribution protection needs, regardless of available three-phase voltage.

In addition, the SEL-751A supports single voltage input. For customers with a single PT input, the SEL-751A will assume balanced voltage input for all protection and metering functions.

Loss-of-Potential Logic

The SEL-751A includes loss-of-potential (LOP) logic that detects one, two, or three blown potential fuses. This patented LOP logic is unique because it does not require settings and is universally applicable. The LOP feature allows the blocking of protection elements to add security during fuse failure.

Synchronism Check

When you order the 5 AVI voltage option card, single-phase voltage (phase-to-neutral or phase-to-phase) is connected to voltage input VS/NS for synchronism check across a circuit breaker (or hot/dead line check). You can use synchronism-check voltage to coordinate reclosing with the optional recloser control.

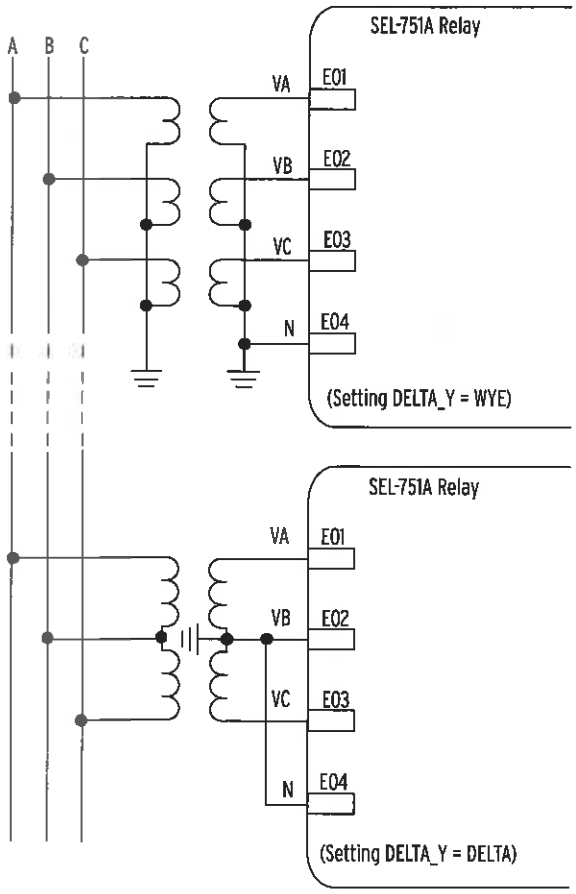


Figure 2 Connect Wye or Open-Delta Voltage to SEL-751A Three-Phase Voltage Inputs

Voltage and Frequency Elements for Extra Protection and Control

Over- and Undervoltage Elements

Phase-to-ground, phase-to-phase, negative-sequence, and residual overvoltage (59) and phase-to-ground or phase-to-phase undervoltage (27) elements in the SEL-751A create the following protection and control schemes:

- Trip/alarm or event report triggers for over- and undervoltage conditions.
- Undervoltage (27) load shedding scheme (having both 27 and 81U load shedding schemes allows detection of system MVAR- and MW-deficient conditions).

Over- and Underfrequency Protection

Six levels of secure overfrequency (81O) or underfrequency (81U) elements detect true frequency disturbances. Use the independently time-delayed output of these elements to shed load or trip local generation. The SEL-751A makes frequency measurements with the voltage input (if available) and switches automatically to current input when voltages are not available.

Implement an internal multistage frequency trip/restore scheme at each breaker location using the multiple over- and underfrequency levels. This method avoids the cost of wiring a complicated trip and control scheme from a separate frequency relay.

Rate-of-Change of Frequency Protection (Optional)

Four independent rate-of-change of frequency elements are provided with individual time delays for use when frequency changes occur, for example, when there is a sudden imbalance between generation and load. They call for control action or switching action such as network decoupling or load shedding. Each element includes logic to detect either increasing or decreasing frequency and above or below nominal frequency.

Fast Rate-of-Change-of-Frequency Protection for Aurora Vulnerability Mitigation (Optional)

The fast rate-of-change of frequency protection, 81RF, provides a faster response compared to frequency (81) and rate-of-change of frequency (81R) elements. The fast operating speed makes the 81RF element suitable for detecting islanding conditions. The element uses a characteristic (see *Figure 3*) based on the frequency deviation from nominal frequency ($\Delta f = FREQ - FNOM$) and the rate-of-change of frequency (DF3C) to detect islanding conditions. A time window of three cycles is used to calculate the value of DF3C. Under steady state conditions, the operating point is close to the origin. During islanding conditions, the operating point enters Trip Region 1 or Trip Region 2 of the characteristic, depending on the acceleration or deceleration of the islanded system. (81RFDFP in Hz) and (81RFRP in Hz/sec) are the settings used to configure the characteristic.

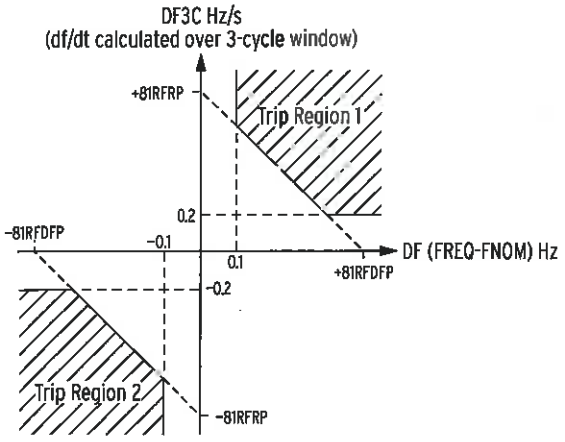


Figure 3 81RF Characteristic

Power Element Protection

The SEL-751A with optional voltage inputs provides two power elements for detecting real (Watts) or reactive (VARS) positive or negative power flow levels for the feeder application. Each power element has a definite-time delay setting.

Arc-Flash Protection

An arcing short circuit or ground fault in low or medium voltage switchgear can cause very serious equipment damage and personal injury. They can also cause prolonged and expensive downtime.

The best way to minimize the impact of an arc-flash event is to reduce the detection and circuit breaker tripping times. Conventional protection may need several cycles to detect the resulting overcurrent fault and trip the breaker. In some cases, there may not be sufficient current to detect an overcurrent fault. Tripping may be delayed hundreds of milliseconds for sensitivity and selectivity reasons in some applications.

The arc-flash detection-based (AFD) protection can act on the circuit breaker in a few milliseconds (2–5 ms). This fast response can limit the arc-flash energy thus preventing injury to personnel and limiting or eliminating equipment damage.

The arc-flash protection option in the SEL-751A relay adds four-channel fiber-optic AFD inputs and protection elements. Each channel has a fiber-optic receiver and an LED-sourced fiber-optic transmitter that continuously self-tests and monitors the optical circuit to detect and alarm for any malfunction.

There are two types of applications supported by the SEL-751A.

Point Sensor Application

The arc is detected by transmitting the arc-flash light captured by the optical diffuser (located appropriately in the switchgear) over a 1000 µm plastic fiber-optic cable to the optical detector in the relay. The relay performs sensor loopback tests on the optical system using an LED-based transmitter to transmit light pulses at regular intervals to the point sensor assembly (over a second fiber-optic cable). If the relay optical receiver does not detect this light, the relay declares a malfunction and alarms. *Figure 4* (top) shows a diagram for the point sensor application.

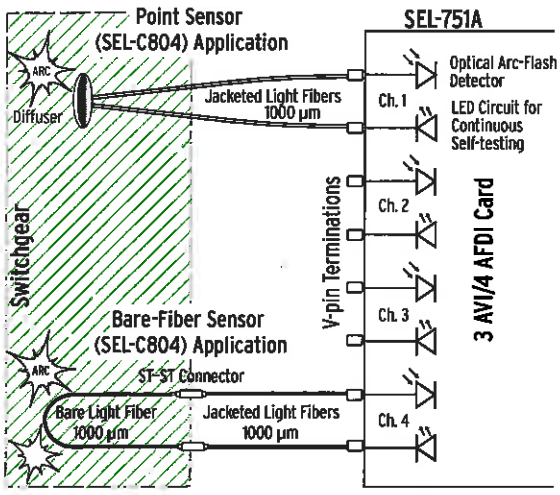


Figure 4 SEL-751A Arc-Flash Detection System

Bare-Fiber Sensor Application

A second option for AFD uses a bare 1000 µm plastic fiber-optic cable located in the switchgear equipment. One end of the fiber is connected to the optical detector in the relay and the other end is connected to the LED transmitter in the relay. The LED transmitter injects periodic light pulses into the fiber as a sensor loopback test to verify the integrity of the loop. The relay detects and alarms for any malfunction. *Figure 4* (bottom) shows a diagram for the bare-fiber sensor application.

The SEL-751A AFD system provides four channels per relay that can be configured for the point sensor or the bare-fiber sensor applications. The optional fast hybrid outputs (high speed and high current) of the relay provide fast-acting trip outputs to the circuit breaker (less than 50 µs). The fast breaker tripping can avoid serious damage or personal injury in case of an arc-flash event. The relay also provides light metering and light event capture to aid in setting the relay and capturing the arc-flash event for records and analysis.

Settable arc-flash phase and neutral overcurrent elements are combined with arc-flash light detection elements to provide secure, reliable, and fast acting arc-flash event protection.

Additional Ordering Options

You can order the following options for any SEL-751A model (see the Model Option Table for details).

- Single or dual, copper or fiber-optic Ethernet port(s), Modbus TCP, SNTP, DNP3 serial and DNP3 LAN/WAN, FTP, Telnet
- IEC 61850
- DeviceNet
- EIA-232 or EIA-485 communications
- Fiber-optic serial port (ST only)
- Additional EIA-232 or EIA-485 port
- Analog I/O (4 AI/4 AO, 8 AI)
- Digital I/O (4 DI/4 DO, 8 DI, 3 DI/4 DO/1 AO, 4 DI/3 DO)
- Voltage options including monitoring package inputs (three-phase voltage input, synchronism-check input, station battery monitor input), advanced monitoring and protection, four-channel fiber-optic AFD inputs and protection, and measured residual current CT input. See *Table 2*.
- 10 RTDs
- Conformal coating for chemically harsh and high moisture environments

Table 2 Voltage Input Options (Sheet 1 of 2)

Voltage Input Options	Option (71)	Option (72)	Option (73)	Option (74)	Option (75/76)
	SELECT 3AVI[a]	SELECT 5AVI[b]	SELECT 5AVI[c]	SELECT 3 AVI/4 AFDI[d]	SELECT 5 AVI/1 ACI[e]
Under- and overvoltage elements (27, 59)	X	X	X	X	X
Voltage based frequency measurement and tracking	X	X	X	X	X
Over-, underfrequency elements (81)	X	X	X	X	X
Power factor elements (55)	X	X	X	X	X
Loss of potential element (60LOP)	X	X	X	X	X
Real, reactive, apparent power, and power factor metering	X	X	X	X	X
Energy metering	X	X	X	X	X
Synchronism-check elements including under- and over-voltage elements (25, 27S, 59S)		X	X		X
Station dc battery voltage monitor		X	X		X
Demand and peak demand metering			X	X	X
Residual overvoltage element (59G)			X	X	X
Negative-sequence overvoltage element (59Q)			X	X	X

Table 2 Voltage Input Options (Sheet 2 of 2)

Voltage Input Options	Option (71)	Option (72)	Option (73)	Option (74)	Option (75/76)
	SELECT 3AVI[a]	SELECT 5AVI[b]	SELECT 5AVI[c]	SELECT 3 AVI/4 AFDI[d]	SELECT 5 AVI/1 ACI[e]
Rate-of-change of frequency element (81R)			X	X	X
Fast rate-of-change of frequency element (81RF), Aurora mitigation			X	X	X
Power elements (32)			X	X	X
4-channel optical arc-flash sensor inputs with continuous self-testing (AFD)				X	
Arc-flash protection elements (50PAF, 50NAF)				X	
Residual current (IG) CT-based residual overcurrent elements (50G, 51G)					X

[a] Voltage Options.
[b] With Monitoring Package.
[c] With Monitoring and Advanced Metering and Protection Packages.
[d] With 4-channel Arc-Flash Detector Inputs and Protection.
[e] SELECT 5AVI/1 ACI With Residual Ground CT Input.

Operator Controls and Reclosing

Operator Controls Eliminate Traditional Panel Control Switches

Four conveniently sized operator controls are located on the relay front panel (see *Figure 5*). You can set the SER to track operator controls. You can also change operator control functions using SELOGIC control equations.

Note: All text can be changed with the configurable labels.

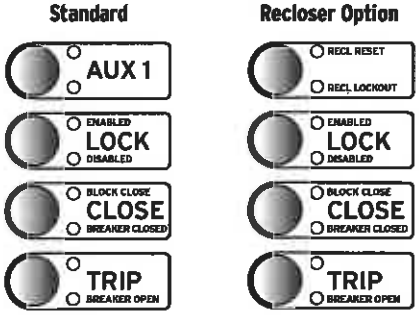


Figure 5 Operator Controls for Standard and Optional Reclosing Models

The following operator control descriptions are for factory-set logic.

In the standard SEL-751A, users can program the top operator control and its corresponding two LEDs. When the SEL-751A is ordered with optional reclosing, the two LEDs are programmed to give the status of the reclosing. The two LEDs, **RECL RESET** and **RECL LOCKOUT**, indicate whether the recloser is in the Reset or Lockout state.

The **{LOCK}** operator control blocks selected functions. Press it for at least three seconds to engage or disengage the lock function. While locked in position, the following operator controls cannot change state if pressed: **{TRIP}** and **{CLOSE}**.

Use the **{CLOSE}** and **{TRIP}** operator controls to close and open the connected circuit breaker. Program with intentional time delays to support operational requirements for breaker-mounted relays. This allows the operator to press the **{CLOSE}** or **{TRIP}** pushbutton, then move to an alternate location before the breaker command is executed.

Programmable Autoreclosing

When ordered with optional reclosing, the SEL-751A can autoreclose a circuit breaker up to four times before lockout. Use SELOGIC control equations to program the SEL-751A to perform the following reclosing functions:

- Allow closing, e.g., when the load-side line is dead, or when the two systems are in synchronism (optional).
- Advance the shot counter without tripping, e.g., when another protective relay clears a fault, also known as sequence coordination.
- Initiate reclosing, e.g., for particular protection trip operations.
- Drive-to-lockout, e.g., when an optoisolated input is deasserted.
- Delay reclosing, e.g., after a trip caused by a close-in, high-duty fault.
- Flexible reclose supervision failure scheme that allows going to lockout or moving to the next available shot.

The reclosing shot counter controls which protective elements are involved in each reclose interval. Applications include fuse- and trip-saving schemes. The front-panel LEDs (Reset and Lockout) track the reclosing state.

Relay and Logic Settings Software

ACSELERATOR QuickSet Software simplifies settings and provides analysis support for the SEL-751A. With ACSELERATOR QuickSet you have several ways to create and manage relay settings:

- Develop settings off-line with an intelligent settings editor that only allows valid settings.
- Create SELOGIC control equations with a drag-and-drop text editor.
- Configure proper settings using online help.
- Organize settings with the relay database manager.
- Load and retrieve settings using a simple PC communications link.

With ACSELERATOR QuickSet you can verify settings and analyze events; and analyze power system events with the integrated waveform and harmonic analysis tools.

The following features of ACSELERATOR QuickSet can monitor, commission, and test the SEL-751A:

- The PC interface will remotely retrieve power system data.
- The Human-Machine Interface (HMI) will monitor meter data, Relay Word bits, and output contacts status during testing. The control window allows resetting of metering quantities, arc-flash sensor testing and diagnostics, and other control functions.

Metering and Monitoring

The SEL-751A provides extensive metering capabilities. See *Specifications on page 19* for metering and power measurement accuracies. As shown in *Table 3*, metered quantities include phase voltages and currents; sequence voltages and currents; power, frequency, and energy; and maximum/minimum logging of selected quantities. The relay reports all metered quantities in primary quantities (current in A primary and voltage in V primary).

Table 3 Metering Capabilities

Quantities[a]	Description
Currents IA, IB, IC, IN, IG	Input currents, residual ground current (IG = 3I0 = IA + IB + IC OR measured IG)
Voltages VA, VB, VC	Wye-connected voltage inputs
Voltages VAB, VBC, VCA	Delta-connected voltage inputs
Voltage VS	Synchronism-check voltage input
Power $kW_{A,B,C,3P}$ $kVAR_{A,B,C,3P}$ $kVA_{A,B,C,3P}$	Single and three-phase kilowatts, kilovars, and kilovolt-amps
Energy MWh3P, MVARh3P-IN, MVARh3P-OUT, MVAh3P	Three-phase megawatt hours, megavar-hours, and megavolt-amp-hours
Power Factor $PF_{A,B,C,3P}$	Single and three-phase power factor (leading or lagging)
Sequence 3I2, 3I0, 3V2, 3V0	Negative- and zero-sequence currents and voltages
Frequency, FREQ (Hz)	Instantaneous power system frequency
Voltage VDC	Station battery voltage
Light Intensity (%) LS1–LS4	Arc-flash light inputs in % of full scale

[a] Single-phase power, energy, and power factor quantities are not available when delta-connected PTs are used.

Load Profile

The SEL-751A features a programmable Load Profile (LDP) recorder that records up to 17 metering quantities into nonvolatile memory at fixed time intervals. The LDP saves several days to several weeks of the most recent data depending on the LDP settings.

Synchronized Phasor Measurement

Combine the SEL-751A with an SEL IRIG-B time source to measure the system angle in real time with a timing accuracy of ±10 µs. Measure instantaneous voltage and current phase angles in real time to improve system operation with synchrophasor information. Replace state measurement, study validation, or track system stability. Use SEL-5077 SYNCHROWAVE® Server Software or SEL-5078 SYNCHROWAVE Console Software to view system angles at multiple locations for precise system analysis and system-state measurement (see *Figure 6*).

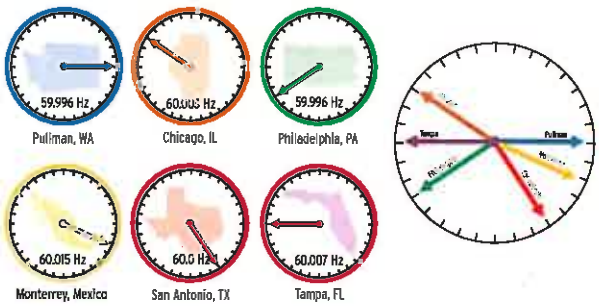


Figure 6 View of System Angle at Multiple Locations

Event Reporting

Event Reports and the SER simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. In response to a user-selected trigger, the voltage, current, frequency, and element status information contained in each event report confirms relay, scheme, and system performance for every fault. Decide how much detail is necessary when you request an event report (e.g., 1/4-cycle or 1/16-cycle resolution, filtered or raw analog data).

The relay stores as many as nineteen of the most recent 64-cycle or as many as seventy-seven of the most recent 15-cycle event reports in nonvolatile memory. The relay always appends relay settings to the bottom of each event report.

The following analog data formats are available:

- 1/4-cycle or 1/16-cycle resolution
- Unfiltered or filtered analog
- ASCII or Compressed ASCII

The relay SER feature stores the latest 1024 entries. Use this feature to gain a broad perspective at a glance. An SER entry helps to monitor input/output change-of-state occurrences and element pickup/dropout.

The IRIG-B time-code input synchronizes the SEL-751A time to within ±1 ms of the time-source input. A convenient source for this time code is the SEL-2401 Satellite-Synchronized Clock or the SEL-2032, SEL-2030, or SEL-2020 Communications Processor (via Serial Port 2 or 3 on the SEL-751A).

Substation Battery Monitor

The SEL-751A relays that include enhanced voltage option with the monitoring package measure and report the substation battery voltage connected to the VBAT terminals. The relay includes two programmable threshold comparators and associated logic for alarm and control. For example, if the battery charger fails, the measured dc falls below a programmable threshold. The SEL-751A alarms to alert operations personnel before the substation battery voltage falls to unacceptable levels. Monitor these thresholds with an SEL communications processor and trigger messages, telephone calls, or other actions.

The measured dc voltage appears in the METER display and the VDC column of the event report. Use the event report column data to see an oscillographic display of the battery voltage. This display shows how much the substation battery voltage drops during trip, close, and other control operations.

Circuit Breaker Contact Wear Monitor

Circuit breakers experience mechanical and electrical wear every time they operate. Intelligent scheduling of breaker maintenance takes into account manufacturer's published data of contact wear versus interruption levels and operation count. With the breaker manufacturer's maintenance curve as input data, the SEL-751A breaker monitor feature compares this input data to the measured (unfiltered) ac current at the time of trip and the number of close-to-open operations.

Every time the breaker trips, it integrates the measured current information. When the result of this integration exceeds the breaker wear curve threshold (*Figure 7*) the relay alarms via output contact, communications port, or front-panel display. This kind of information allows timely and economical scheduling of breaker maintenance.

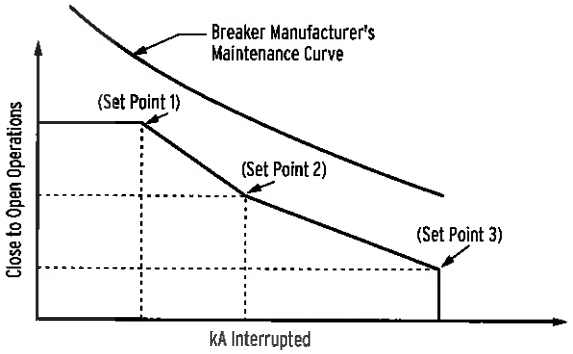


Figure 7 Breaker Contact Wear Curve and Settings

Automation

Flexible Control Logic and Integration Features

The SEL-751A is equipped with as many as four independently operated serial ports: one EIA-232 port on the front, one EIA-232 or EIA-485 port on the rear, and one fiber-optic port. Additionally, the SEL-751A has one EIA-232 or EIA-485 port option card. Optionally, the relay supports single or dual , copper or fiber-optic Ethernet ports. The relay does not require special communications software. You can use any system that emulates a standard terminal system. Establish communication by connecting: computers; modems; protocol converters; printers; an SEL-2032, SEL-2030 or SEL-2020 Communications Processor; SCADA serial port; and/or RTUs for local or remote communication. Refer to *Table 4* for a list of communications protocols available in the SEL-751A.

Table 4 Communications Protocols

Type	Description
Simple ASCII	Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter and Fast Operate	Binary protocol for machine-to-machine communications. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while a technician is transferring an event report.
Fast SER Protocol	Provides SER events to an automated data collection system.
Modbus	Serial- or Ethernet-based Modbus with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and setting groups.
DNP3	Serial or Ethernet-based DNP3 protocols. Provides default and mappable DNP3 objects that include access to metering data, protection elements, Relay Word bits, contact I/O, targets, SER, relay summary event reports, and setting group selection.
IEC 61850	Ethernet-based international standard for interoperability between intelligent devices in a substation. Operates remote bits and I/O. Monitors Relay Word bits and analog quantities.
Synchrophasors	IEEE C37.118-compliant synchrophasors for system state, response, and control capabilities.
Event Messenger	The SEL-3010 allows users to receive alerts sent directly to their cell phone. Alerts can be triggered through relay events and can include quantities measured by the relay.
DeviceNet	Allows for connection to a DeviceNet network for access to metering data, protection elements, contact I/O, targets, and setting groups.
SNTP	Ethernet-based protocol that provides time synchronization of the relay.

Apply an SEL communications processor as the hub of a star network, with point-to-point fiber or copper connection between the hub and the SEL-751A (*Figure 8*).

The communications processor supports external communications links including the public switched telephone network for engineering access to dial-out alerts and private line connections of the SCADA system.

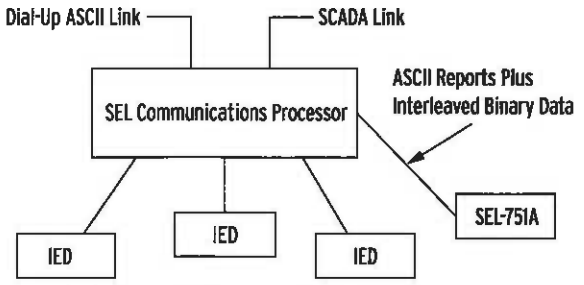


Figure 8 Example Communication System

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Consult your SEL representative for more information on cable availability.

SEL-751A control logic improves integration in the following ways:

- Replaces traditional panel control switches. Eliminate traditional panel control switches with 32 local bits. Set, clear, or pulse local bits with the front-panel pushbuttons and display. Program the local bits into your control scheme with SELOGIC control equations. Use the local bits to perform functions such as a trip test or a breaker trip/close.
- Eliminates RTU-to-relay wiring. Eliminate RTU-to-relay wiring with 32 remote bits. Set, clear, or pulse remote bits using serial port commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip, close, and settings group selection.
- Replaces traditional latching relays. Replace up to 32 traditional latching relays for such functions as "remote control enable" with latch bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the relay loses power.
- Replaces traditional indicating panel lights. Replace traditional indicating panel lights with 32 programmable displays. Define custom messages (e.g., `Breaker Open`, `Breaker Closed`) to report power system or relay conditions on the front-panel display. Use Advanced SELOGIC control equations to control which messages the relay displays.
- Eliminate external timers. Eliminate external timers for custom protection or control schemes with 32 general purpose SELOGIC control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.
- Eliminate settings changes. Selectable setting groups make the SEL-751A ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions.

The relay stores three setting groups. Select the active setting group by optoisolated input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies.

Switching setting groups switches logic and relay element settings. Program groups for different operating conditions, such as feeder paralleling, station maintenance, seasonal operations, emergency contingencies, loading, source changes, and downstream relay setting changes.

Fast SER Protocol

SEL Fast SER Protocol provides SER events to an automated data collection system. SEL Fast SER Protocol is available on any rear serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-751A relays.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

Ethernet Network Architectures

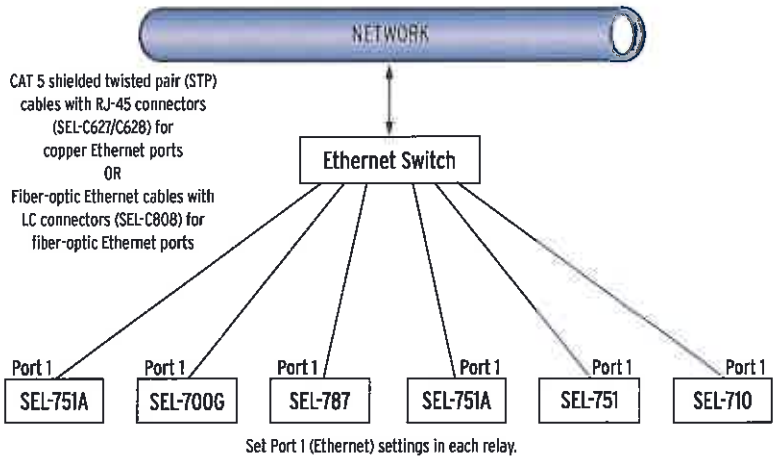


Figure 9 Simple Ethernet Network Configuration

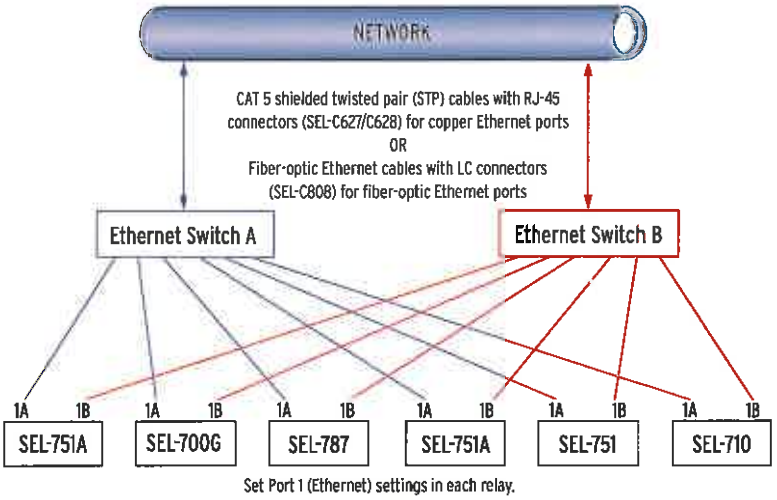


Figure 10 Simple Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

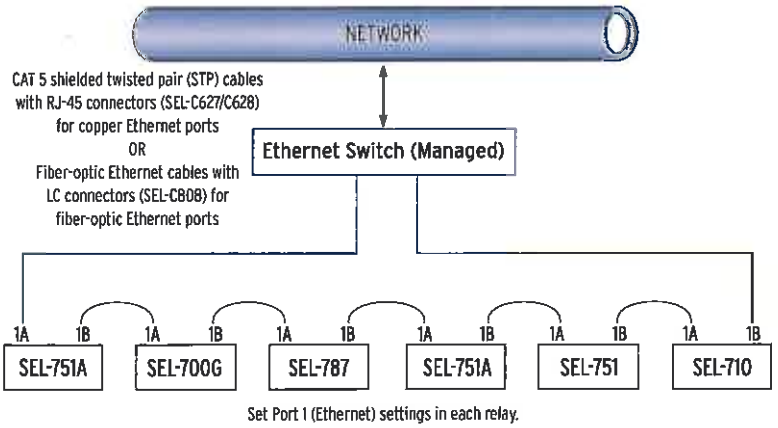


Figure 11 Simple Ethernet Network Configuration With Ring Structure (Switched Mode)

Additional Features

MIRRORED BITS Relay-to-Relay Communications

The SEL-patented MIRRORED BITS communications technology provides bidirectional relay-to-relay digital communications. MIRRORED BITS can operate independently on up to two EIA-232 rear serial ports and one fiber-optic rear serial port on a single SEL-751A.

This bidirectional digital communication creates eight additional virtual outputs (transmitted MIRRORED BITS) and eight additional virtual inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS mode (see *Figure 12*). Use these MIRRORED BITS to transmit/receive information between upstream relays and a downstream recloser control (e.g., SEL-351R) to enhance coordination and achieve faster tripping for downstream faults. MIRRORED BITS technology also helps reduce total scheme operating time by eliminating the need to assert output contacts to transmit information.

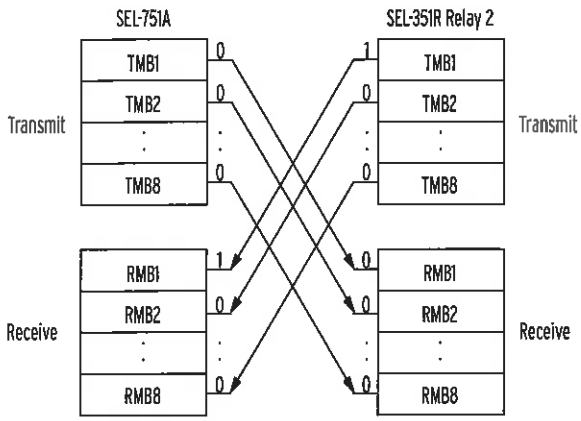


Figure 12 MIRRORED BITS Transmit and Receive Bits

Status and Trip Target LEDs

The SEL-751A includes 16 status and trip target LEDs on the front panel. When shipped from the factory, all LEDs are predefined and fixed in settings. You can reprogram these LEDs for specific applications. This combination of targets is explained and shown in *Figure 14*. Some front-panel relabeling of LEDs may be needed if you reprogram them for unique or specific applications—see *Configurable Labels*.

Event Messenger Points

The SEL-751A, when used with the SEL-3010 Event Messenger, can allow for ASCII-to-voice translation of as many as 32 user-defined messages, along with analog data that has been measured or calculated by the relay. This combination can allow the user to receive voice messages on any phone for alerts to transition of any Relay Word bits in the relay.

Verbal notification of breaker openings, fuse failures, RTD alarms, etc. can now be sent directly to your cell phone through the use of your SEL-751A and SEL-3010 (must be connected to an analog telephone line). In addition, messages can include an analog value such as current, voltage, or power measurements made by the SEL-751A.

Configurable Labels

Use the optional configurable labels to relabel the operator controls and LEDs (shown in *Figure 14*) to suit the installation requirements. This feature includes preprinted labels (with factory default text), blank label media, and a Microsoft® Word template on CD-ROM. This allows quick, professional-looking labels for the SEL-751A. Labels may also be customized without the use of a PC by writing the new label on the blank stock provided. The ability to customize the control and indication features allows specific utility or industry procedures to be implemented without the need for adhesive labels. All of the figures in this data sheet show the factory default labels of the SEL-751A, including the standard model shown in *Figure 14*.

Guideform Specification

Feeder protection shall be provided by a microprocessor-based relay equipped with the following protection, monitoring, control, automation, and reporting functions. Self-checking functions shall be included. Specific requirements are as follows.

Protection and Control

- Phase, neutral, residual, and negative-sequence overcurrent elements (50P/50N/50G/50Q)
- Phase, neutral, residual, and negative-sequence time-overcurrent elements (51P/51N/51G/51Q)
- Current-based over- and underfrequency (81)
- Breaker/contactor failure
- Autoreclosing control (79)

Optionally, the relay shall provide the following protection elements.

- Arc-flash detection and arc-flash overcurrent (50PAF, 50NAF)
- Over- and undervoltage (59, 59G, 59Q, 27)
- Power elements (32)
- Power factor (55)
- Voltage-based over- and underfrequency (81)
- Rate-of-change of frequency (81R)
- Loss-of-potential (60)
- Synchronism check (25)
- Measured residual overcurrent (50G/51G)
- Fast rate-of-change of frequency (81RF) for Aurora mitigation

Temperature Inputs

Availability of up to 12 RTD inputs in an external module (SEL-2600 with ST option) or 10 RTD inputs with an internal card, which, when included, shall have the following features:

- Optical fiber transmission of RTD temperatures (using SEL-2600) to relay: range > 1000 m
- Separately field-selected RTD types: Pt100, Ni100, Ni120, or Cu10
- Noise immunity (50 Hz and higher) on RTD inputs up to 1.4 Vac_{peak}
- One contact input (with SEL-2600)

Automation

- 32 local control logic points, 32 remote control logic points, 32 latching logic points, 32 counters, 32 math variables, 32 logic variables, and 32 timers
- SELOGIC control equations with Boolean and math equations capability for logic and control

Communications/Integration

- ASCII, Modbus RTU, DeviceNet, Event Messenger, MIRRORED BITS, SNTP, Telnet, FTP, Modbus TCP, DNP3 serial and LAN/WAN, IEEE C37.118 (synchrophasor data), and IEC 61850 protocols
- One front-panel EIA-232 port and one rear-panel EIA-232 or EIA-485 port, one optional ST fiber-optic serial port, and an optional single or dual, copper or fiber-optic Ethernet port(s)
- Capability for an additional rear-panel EIA-232 or EIA-485 port
- Windows®-based PC software for setting, report retrieval, metering, HMI, and control.

Front-Panel Visualization

- The front panel shall be capable of displaying measured values, calculated values, I/O status, device status, and configuration parameters on a front-panel LCD display.
- The display shall have a rotating capability to display custom messages and data. Thirty-two display messages shall be provided.
- The front panel shall also have a minimum of six user-programmable LEDs and four user-programmable pushbutton controls with eight programmable LEDs.

Monitoring and Reporting

- Load-profile monitoring: Provide periodic snapshot (selectable rate from every 5 to 60 minutes) of up to 17 selectable analog quantities
- Metering: The relay shall include metering capabilities for real-time current, voltage, power, energy qualities, and phase demand and peak demand current and power values. RTD temperature metering, synchrophasor data metering, and minimum/ maximum metering shall also be included. The arc-flash protection shall include light metering.
- Event summaries: Fault type and trip data, including time of tripping
- Event reports: 15-cycle length (up to 77 reports) or 64-cycle length (up to 19 reports) with 4 or 16 samples/cycle resolution
- SER: Up to 1024 time-tagged, most recent input, output, and element transitions
- Data stored in nonvolatile, Flash memory
- Station battery monitor with two levels of detection (monitoring package)
- Breaker wear monitoring
- Event report with arc-flash light input

Synchronized Phasor Measurements

- The relay shall provide high-accuracy phasor measurements for voltages and currents if an IRIG-B signal is available.
- The relay shall provide a selectable synchrophasor data update rate of 1–10 times per second.

Hardware

- Operating temperature range of –40° to +85°C
- Power supply input operating voltage range of 24/48 Vdc, 125/250 Vdc, or 120/240 Vac
- Demodulated IRIG-B time-synchronization input capability
- Optional 10 internal RTD inputs or 12 external RTD inputs
- 5 A or 1 A, ac current inputs IA, IB, IC, and IN with optional 2.5 mA or 50 mA sensitive IN input
- Optional 5 A or 1 A ac residual current input IG
- 300 V maximum, 3 ac voltage inputs, synchronism-check voltage input, station battery voltage input, and arc-flash detection (AFD) inputs
- Electromechanical or optional fast hybrid (high-speed, high-current interruption) digital outputs
- Optoisolated digital inputs
- Jumper-selectable current (up to ±20 mA range) or voltage (up to ±10 V range) analog inputs
- Relay front panel shall meet the requirements of NEMA 12/IP65
- Class 1, Division 2 Hazardous Locations certification

Service and Support

- Reliability: The vendor shall supply the actual measured Mean Time Between Failures (MTBF) for the device upon request.
- Manufacturer: The device shall be manufactured in the U.S.A.
- Conformal Coating: The device shall have optional conformal coating to protect the circuit boards from harsh environments.
- Warranty: The device shall include a ten-year, no-questions-asked warranty for all material and workmanship defects. In addition, the warranty shall cover accidental, customer-induced damage.

Wiring Diagrams

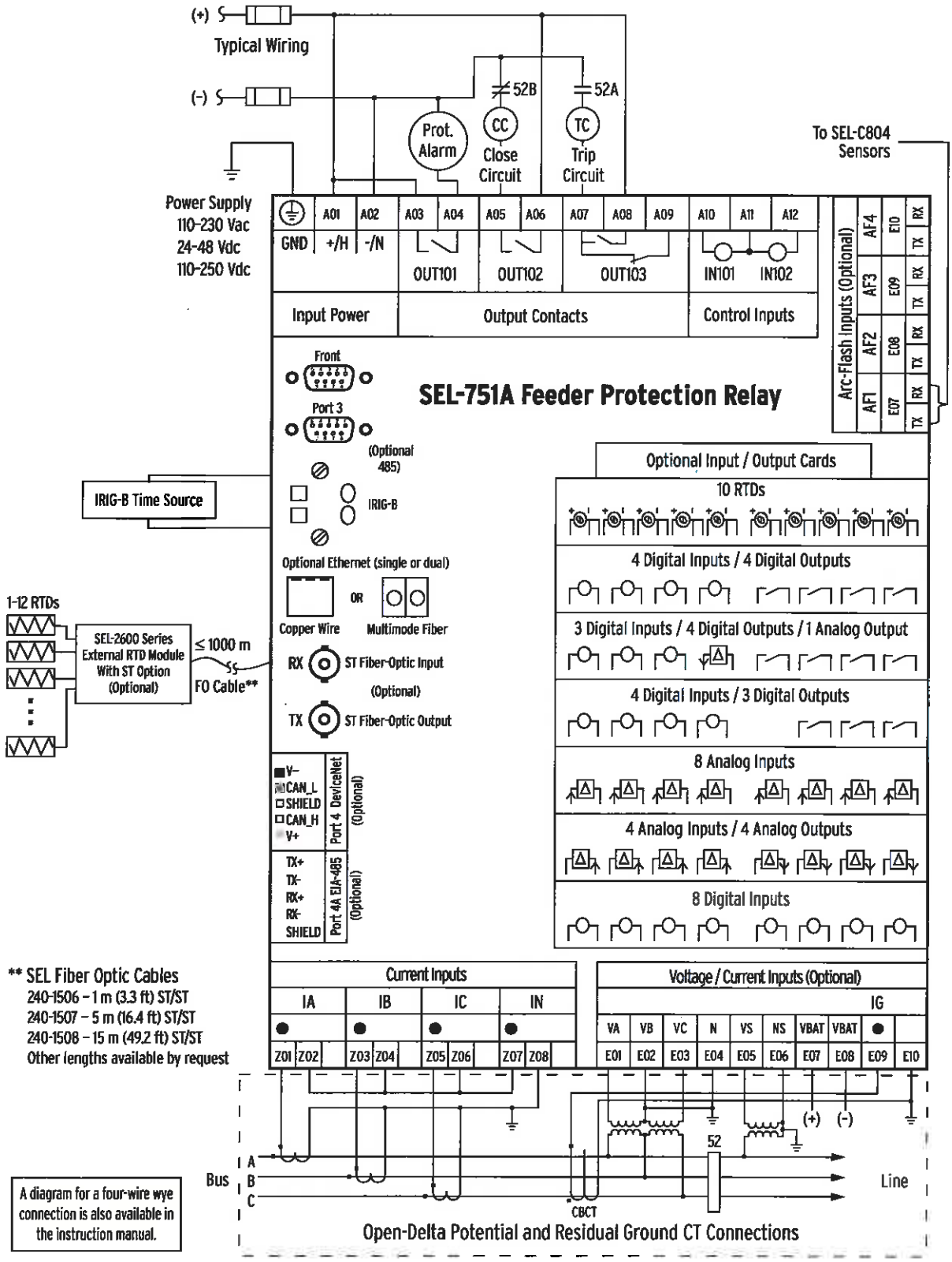


Figure 13 Wiring Diagram SEL-751A

Panel Diagrams

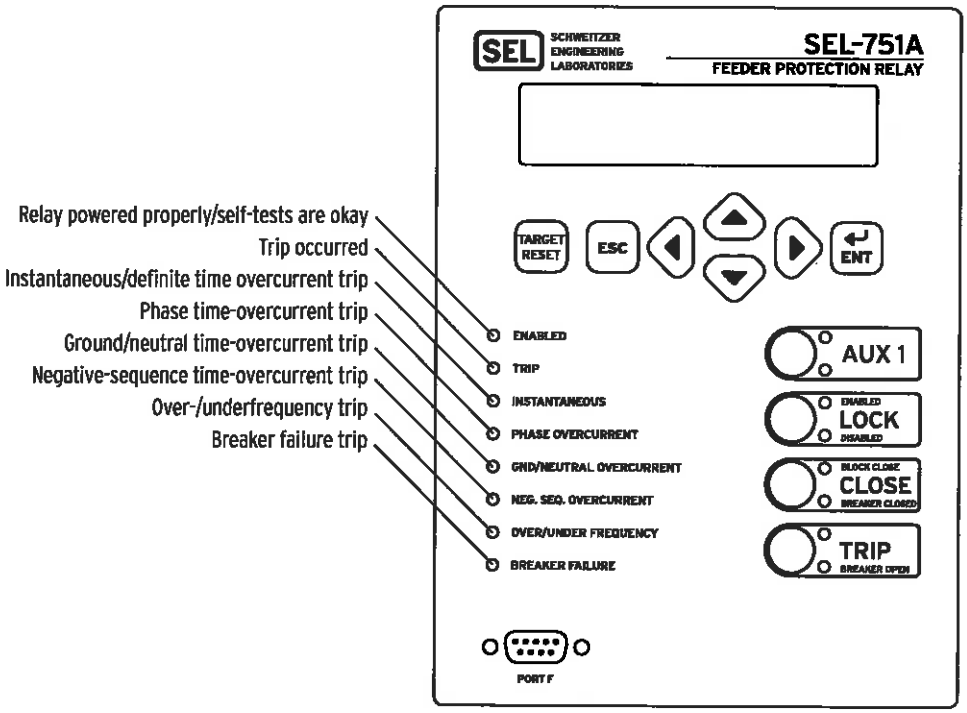
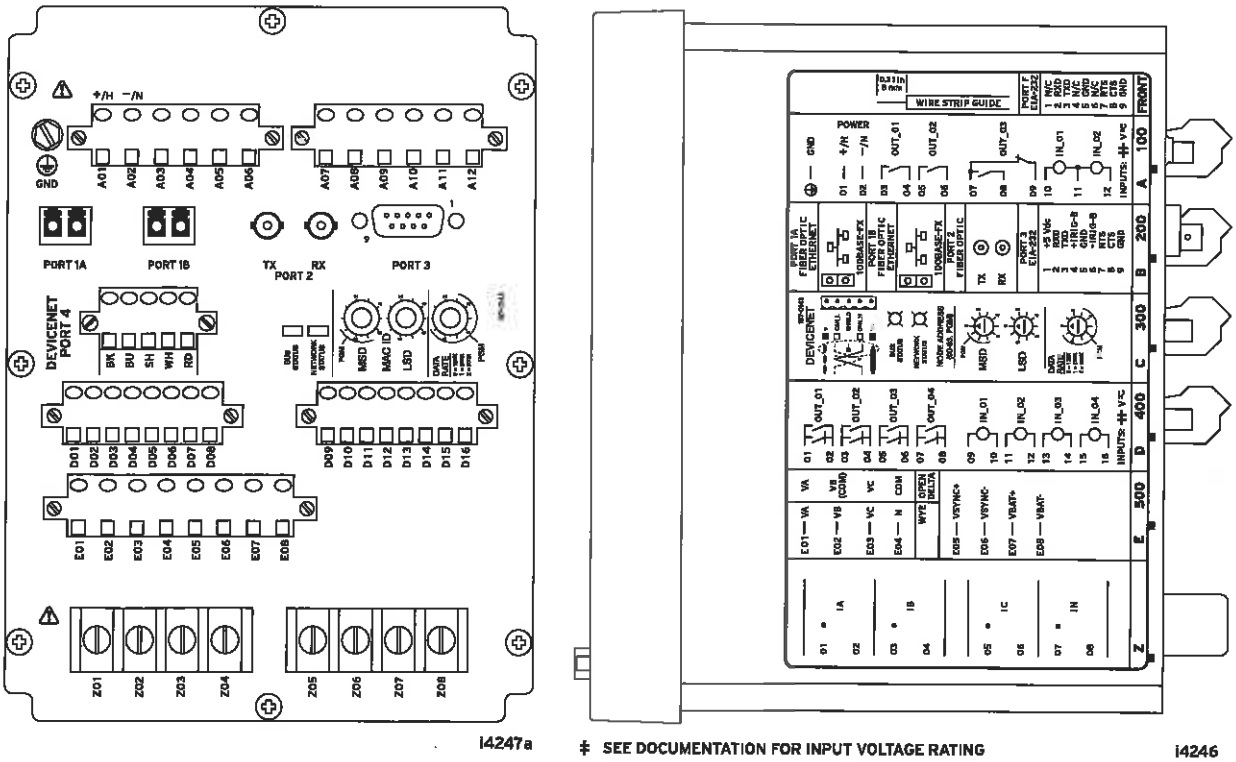


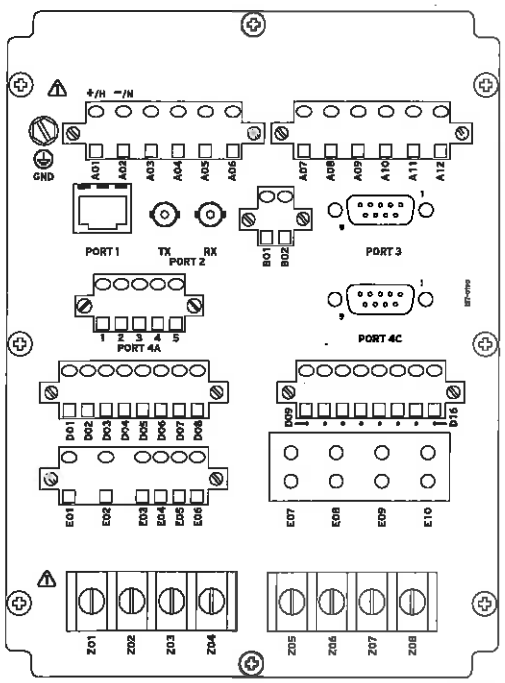
Figure 14 Front Panel With Default Configurable Labels



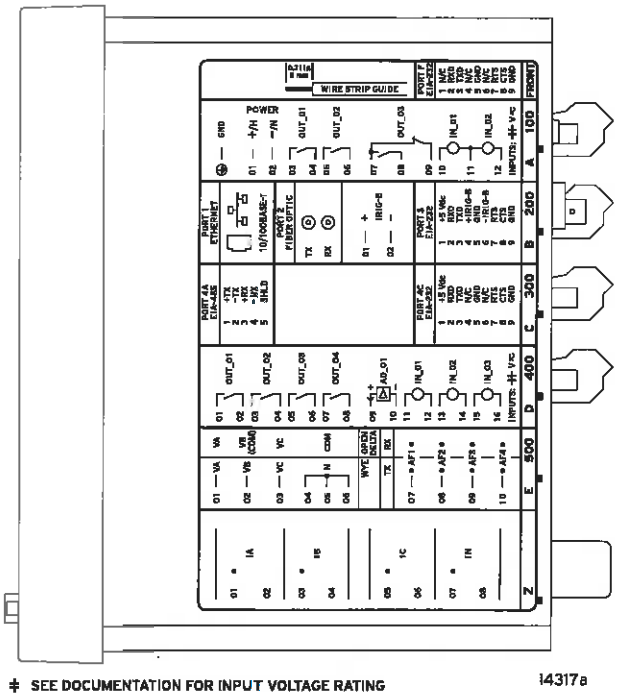
(A) Rear-Panel Layout

(B) Side-Panel Input and Output Designations

Figure 15 Dual Fiber Ethernet With Enhanced Voltage Option With Monitoring Package, DeviceNet, Fiber-Optic Serial Port, and Fast Hybrid 4 DI/4 DO

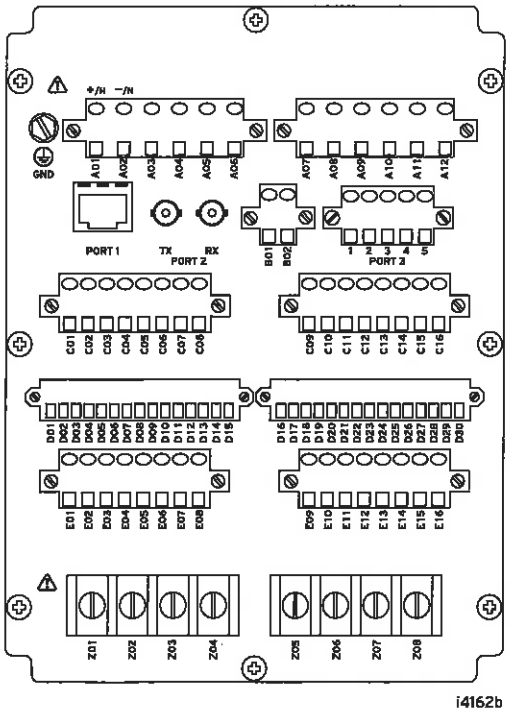


(A) Rear-Panel Layout

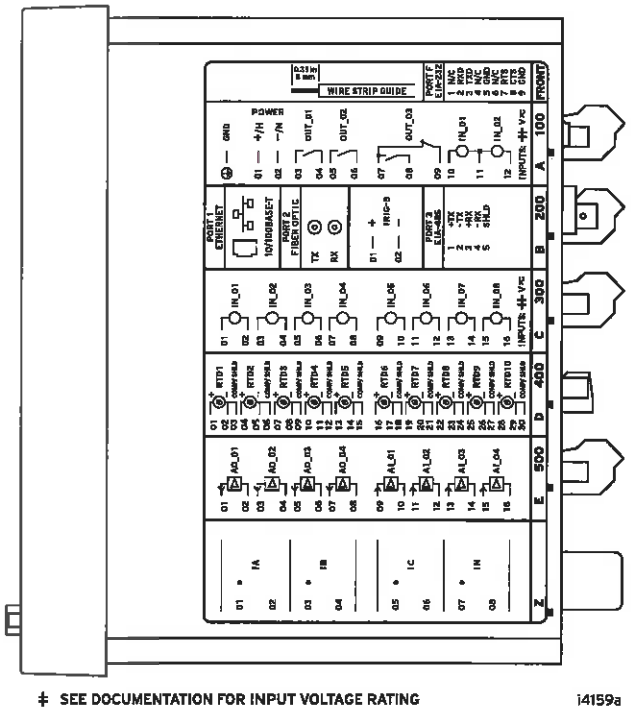


(B) Side-Panel Input and Output Designations

Figure 16 Fiber-Optic Serial, Ethernet, EIA-232 Communication, 4 DO/3 DI/1 AO, and 3 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs

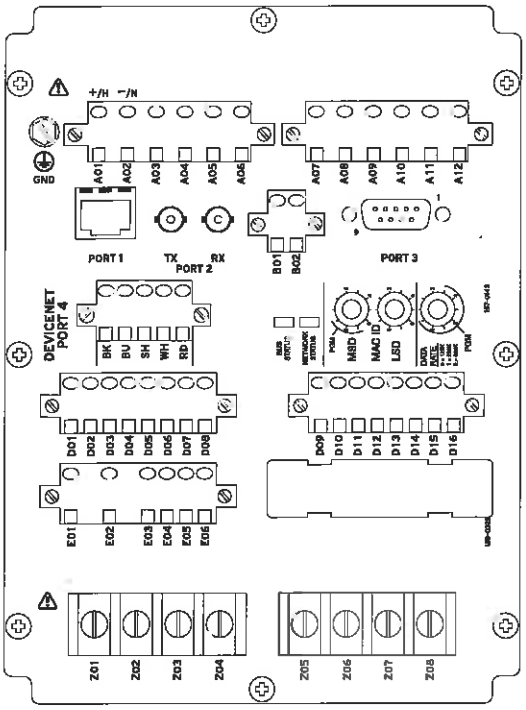


(A) Rear-Panel Layout

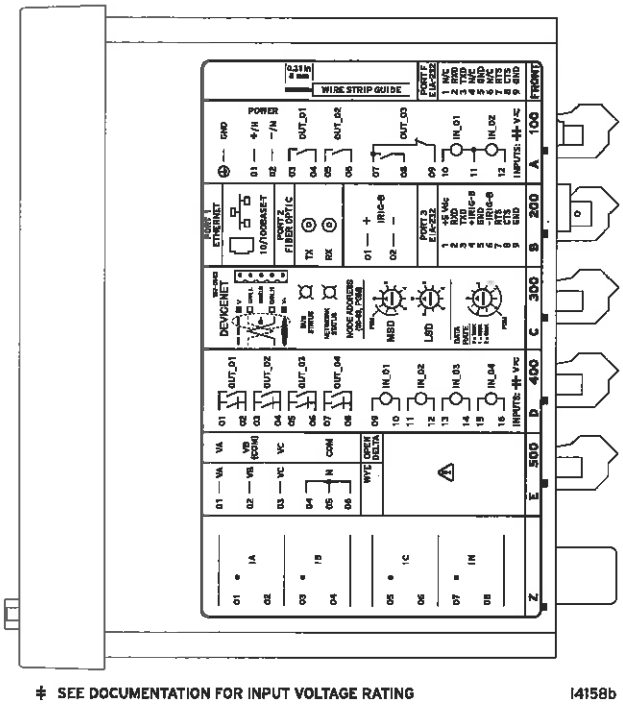


(B) Side-Panel Input and Output Designations

Figure 17 Fiber-Optic Serial, Ethernet, 8 DI, RTD, and 4 AI/4 AO Option



(A) Rear-Panel Layout



(B) Side-Panel Input and Output Designations

Figure 18 Fiber-Optic Serial, DeviceNet, Fast Hybrid 4 DI/4 DO, and Voltage Option

Relay Dimensions

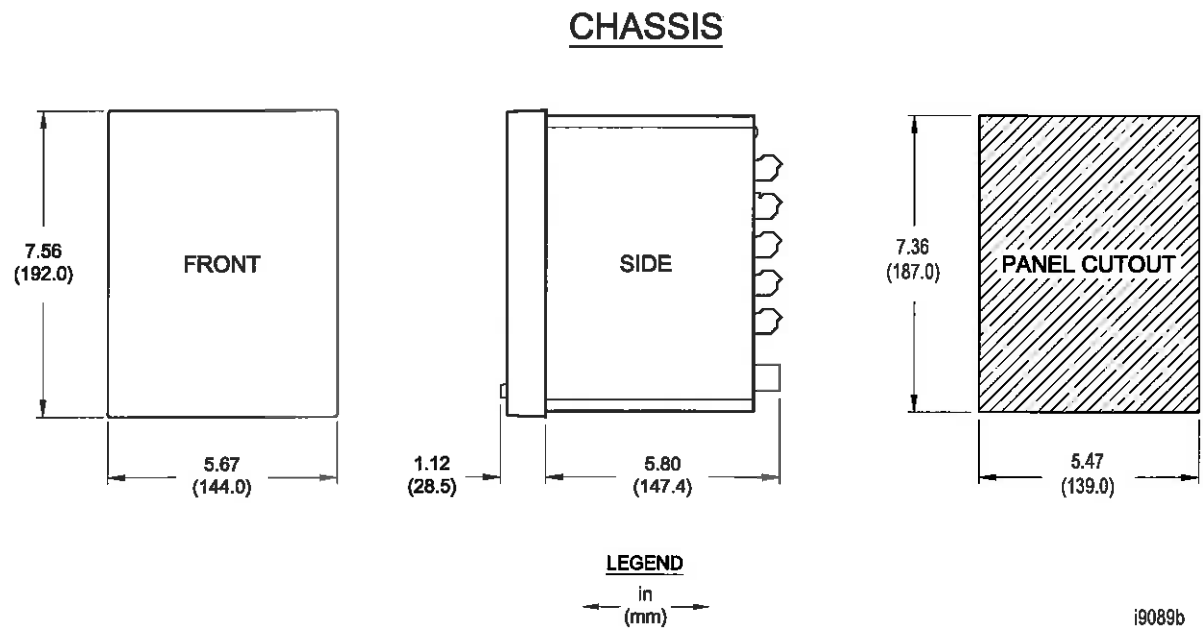


Figure 19 SEL-751A Dimensions for Rack- and Panel-Mount Models

Specifications

General

AC Current Input

Phase, Neutral, and Residual Currents

I_{NOM} = 1 A, 5 A, 50 mA, or 2.5 mA (high sensitivity) secondary depending on model.

INOM = 5 A

Rated Range (X/R = 40):	0.10–100.00 A
Continuous Rating:	15 A
1 Second Thermal:	500 A
Rated Frequency:	50/60 ± 5 Hz
Burden (Per Phase):	<0.1 VA

INOM = 1 A

Rated Range (X/R = 40):	0.02–20.00 A
Continuous Rating:	15 A
1 Second Thermal:	100 A
Rated Frequency:	50/60 ± 5 Hz
Burden (Per Phase):	<0.01 VA

INOM = 50 mA

Rated Range (X/R = 40):	5.0–1000.0 mA
Continuous Rating:	15 A
1 Second Thermal:	100 A
Rated Frequency:	50/60 ± 5 Hz
Burden (Per Phase):	<2 mVA

INOM = 2.5 mA

Rated Range (X/R = 40):	0.13–12.50 mA
Continuous Rating:	15 A
1 Second Thermal:	100 A
Rated Frequency:	50/60 ± 5 Hz
Burden (Per Phase):	<0.1 mVA
Measurement Category:	II

AC Voltage Inputs

Rated Operating Voltage (U_e):	100–250 Vac
Rated Continuous Voltage:	300 Vac
10 Second Thermal:	600 Vac
Rated Frequency:	50/60 ± 5 Hz
Burden:	<0.1 VA
Input Impedance:	10 Mohm differential 5 Mohm common mode

Power Supply

125/250 Vdc or 120/240 Vac

Rated Supply Voltage:	110–240 Vac, 50/60 Hz 110–250 Vdc
Input Voltage Range:	85–264 Vac 85–275 Vdc
Power Consumption:	<40 VA (ac) <20 W (dc)
Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

24/48 Vdc

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range:	19.2–60 Vdc
Power Consumption:	<20 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Output Contacts

General

OUT103 is Form C Trip output, all other outputs are Form A, except for the SELECT 4 DI/3 DO card, which supports one Form-B and two Form-C outputs.

Mechanical Durability:	10,000 no load operations
Pickup/Dropout Time:	≤8 ms (coil energization to contact closure)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
Thermal:	50 A for 1 s
Contact Protection:	360 Vdc, 40 J MOV protection across open contacts

Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974:

24 Vdc	.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic (2.5 Cycles/Second) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

AC Output Ratings

Maximum Operational Voltage (U_e) Rating:	240 Vac
Insulation Voltage (U_i) Rating (Excluding EN 61010-1):	300 Vac
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Voltage Protection Across Open Contacts:	270 Vac, 40 J
Rated Operational Current (I_e):	3 A @ 120 Vac 1.5 A @ 240 Vac
Conventional Enclosed Thermal Current (I_{the}) Rating:	5 A
Rated Frequency:	50/60 ± 5 Hz

Electrical Durability Make VA Rating:	3600 VA, cos ϕ = 0.3
Electrical Durability Break VA Rating:	360 VA, cos ϕ = 0.3

UL/CSA Digital Output Contact Temperature Derating for Operating at Elevated Temperatures

Digital Output Cards Installed	Operating Ambient	Maximum Value of Current (I_{the})	Duty Factor
1–3	less than or equal to 60°C	5.0 A	Continuous
1–3	between 60°C and 70°C	2.5 A	Continuous

Fast Hybrid (High-Speed, High-Current Interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection (Maximum Voltage):	250 Vac/330 Vdc
Pickup Time:	< 50 µs, resistive load
Dropout Time:	< 8 ms, resistive load

Break Capacity (10000 Operations):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

NOTE: Per IEC 60255-23:1994, using the simplified method of assessment.
NOTE: Make rating per IEEE C37.90-1989.

Optoisolated Control Inputs

When Used With DC Control Signals

250 V:	ON for 200–312.5 Vdc OFF below 150 Vdc
220 V:	ON for 176–275 Vdc OFF below 132 Vdc
125 V:	ON for 100–156.2 Vdc OFF below 75 Vdc
110 V:	ON for 88–137.5 Vdc OFF below 66 Vdc
48 V:	ON for 38.4–60 Vdc OFF below 28.8 Vdc
24 V:	ON for 15–30 Vdc OFF for <5 Vdc

When Used With AC Control Signals

250 V:	ON for 170.6–312.5 Vac OFF below 106 Vac
220 V:	ON for 150.2–275 Vac OFF below 93.3 Vac
125 V:	ON for 85–156.2 Vac OFF below 53 Vac
110 V:	ON for 75.1–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 32.8–60 Vac OFF below 20.3 Vac
24 V:	ON for 14–30 Vac OFF below 5 Vac

Current Draw at Nominal DC Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

Analog Output (Optional)

	1A0	4A0
Current:	4–20 mA	±20 mA
Voltage:	—	±10 V
Load at 1 mA:	—	0–15 kΩ
Load at 20 mA:	0–300 Ω	0–750 Ω
Load at 10 V:	—	>2000 Ω
Refresh Rate:	100 ms	100 ms
% Error, Full Scale, at 25°C:	<±1%	<±0.55%
Select From:	Analog quantities available in the relay	

Analog Inputs (Optional)

Maximum Input Range:	±20 mA ±10 V Operational range set by user
Input Impedance:	200 Ω (current mode) >10 kΩ (voltage mode)
Accuracy at 25°C:	
With User Calibration:	0.05% of full scale (current mode) 0.025% of full scale (voltage mode)
Without User Calibration:	Better than 0.5% of full scale at 25°C
Accuracy Variation With Temperature:	±0.015% per °C of full-scale (±20 mA or ±10 V)

Arc-Flash Detectors (Optional)

Multimode fiber-optic receiver/transmitter pair

Fiber Type:	1000 µm diameter, 640 nm wavelength, plastic, bare, or jacketed
Connector Type:	V-Pin

Frequency and Phase Rotation

System Frequency:	50, 60 Hz
Phase Rotation:	ABC, ACB
Frequency Tracking:	15–70 Hz

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ
Accuracy:	Relay time is synchronized to within ±1 ms of time-source input.
Simple Network Time Protocol (SNTP) Accuracy Internal Clock:	±5 ms

Communications Ports

Standard EIA-232 (2 Ports)

Location:	Front Panel Rear Panel
Data Speed:	300–38400 bps

EIA-485 Port (Optional)

Location:	Rear Panel
Data Speed:	300–19200 bps

Ethernet Port (Optional)

Single/Dual 10/100BASE-T copper (RJ-45 connector)
Single/Dual 100BASE-FX (LC connector)

Multimode Fiber-Optic Port (Optional)

Location:	Rear panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength:	1300 nm
Optical Connector Type:	LC
Fiber Type:	Multimode
Link Budget:	16.1 dB
Typical TX Power:	–15.7 dBm
RX Min. Sensitivity:	–31.8 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~6.4 Km
Data Rate:	100 Mb
Typical Fiber Attenuation:	–2 dB/Km

Port 2 Serial

Wavelength:	820 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Link Budget:	8 dB
Typical TX Power:	–16 dBm
RX Min. Sensitivity:	–24 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~1 Km
Data Rate:	5 Mb
Typical Fiber Attenuation:	–4 dB/Km

Channels 1-4 Arc-Flash Detectors (AFDI)

Wavelength:	640 nm
Optical Connector Type:	V-Pin
Fiber Type:	Multimode
Link Budget:	27 dB
Typical TX Power:	–12 dBm
RX Min. Sensitivity:	–39 dBm
Fiber Size:	1000 µm
Approximate Range:	To 35 m (Point Sensor) To 70 m (Bare–Fiber Sensor)
Data Rate:	NA
Typical Fiber Attenuation:	–0.15 dB/m

Optional Communications Cards

Option 1:	EIA-232 or EIA-485 communications card
Option 2:	DeviceNet communications card

Communications Protocols

SEL, Modbus, DNP3, FTP, TCP/IP, Telnet, SNTP, IEC 61850, MIRRORED BITS, EVMSG, C37.118 (synchrophasors) and DeviceNet.

Operating Temperature

IEC Performance Rating (Per IEC/EN 60068-2-1 & 60068-2-2): –40° to +85°C (–40° to +185°F)

NOTE: Not applicable to UL applications.
NOTE: LCD contrast impaired for temperatures below –20°C and above +70°C.

DeviceNet Communications Card Rating: +60°C (140°F) maximum

Operating Environment

Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5–95%, noncondensing
Maximum Altitude:	2000 m

Dimensions

144.0 mm (5.67 in.) x 192.0 mm (7.56 in.) x 147.4 mm (5.80 in.)

Weight

2.7 kg (6.0 lbs)

Relay Mounting Screws (#8-32) Tightening Torque

Minimum:	1.4 Nm (12 in-lb)
Maximum:	1.7 Nm (15 in-lb)

Terminal Connections

Terminal Block

Screw Size:	#6
Ring Terminal Width:	0.310" maximum

Terminal Block Tightening Torque

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Compression Plug Tightening Torque

Minimum:	0.5 Nm (4.4 in-lb)
Maximum:	1.0 Nm (8.8 in-lb)

Compression Plug Mounting Ear Screw Tightening Torque

Minimum:	0.225 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel IP20 for terminals IP54 rated terminal dust protection assembly (SEL Part #915900170). 10°C temperature derating applies to the temperature specifications of the relay.
Vibration Resistance:	IEC 60068-2-6:2007 3 G, 10–150 Hz IEC 60255-21-1:1988, Class 1 IEC 60255-21-3:1993, Class 2
Shock Resistance:	IEC 60255-21-2:1988, Class 1

Cold:	IEC 60068-2-1:2007 –40°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 40°C, 93% relative humidity, 4 days
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 85°C, 16 hours

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-5:2000 IEEE C37.90-2005 2.5 kVac on current inputs, ac voltage inputs, contact I/O 2.0 kVac on analog inputs 1.0 kVac on analog outputs 2.83 kVdc on power supply
Impulse:	IEC 60255-5:2000 IEEE C37.90-2005 0.5 J, 4.7 kV on power supply, contact I/O, ac current and voltage inputs 0.5 J, 530 V on analog outputs

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-22-2:2008 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-22-3:2007 10 V/m IEEE C37.90.2-2004 35 V/m
Digital Radio Telephone RF Immunity:	ENV 50204:1995
Fast Transient, Burst Immunity:	IEC 61000-4-4:2004 IEC 60255-22-4:2008 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity:	IEC 61000-4-5:2005 IEC 60255-22-5:2008 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2002 2.5 kV oscillatory 4 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-22-6: 2001 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 1000 A/m for 3 seconds 100 A/m for 1 minute IEC 61000-4-9: 2001 1000 A/m
Power Supply Immunity:	IEC 60255-11:2008

EMC Emissions

Conducted Emissions:	EN 55011:1998, Class A IEC 60255-25:2000
Radiated Emissions:	EN 55011:1998, Class A IEC 60255-25:2000

Electromagnetic Compatibility

Product Specific:	EN 50263:1999

Certifications

ISO 9001:	This product was designed and manufactured under an ISO 9001 certified quality management system.
UL, cUL*:	Protective Relay Category NRGU, NRGU7 per UL 508, C22.2 No. 14

* UL has not yet developed requirements for products intended to detect and mitigate an arc flash; consequently, UL has not evaluated the performance of this feature. While UL is developing these requirements, it will place no restriction on the use of this product for arc-flash detection and mitigation. For test results performed by an independent laboratory and other information on the performance and verification of this feature, please contact SEL customer service.

CSA:	C22.2 No. 61010-1
CE:	CE Mark–EMC Directive Low Voltage Directive IEC 61010-1:2001 IEC 60947-1 IEC 60947-4-1 IEC 60947-5-1
Hazardous Locations Approvals:	Complies with UL1604, ISA 12.12.01, CSA 22.2 No. 213, and EN 60079-15 (Class 1, Division 2).

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	16 samples per power system cycle
Frequency Tracking Range:	15–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 100 ms)
Arc Flash Processing:	Arc Flash light is sampled 32 times per cycle. Arc Flash current, light, and 2 fast hybrid outputs are processed 16 times per cycle.

Oscillography

Length:	15 or 64 cycles
Sampling Rate:	16 samples per cycle, unfiltered 4 samples per cycle, filtered
Trigger:	Programmable, using Boolean expressions
Format:	ASCII and Compressed ASCII
Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy:	±5 ms

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (With Respect to Time Source):	±5 ms

Relay Elements

Instantaneous/Definite-Time Overcurrent (50P, 50G, 50N, 50Q)

Pickup Setting Range, A Secondary

5 A Models:	0.50–100.00 A, 0.01 A steps
1 A Models:	0.10–20.00 A, 0.01 A steps
50 mA Models:	5.0–1000.0 mA, 0.1 mA steps
2.5 mA Models:	0.13–12.50 mA, 0.01 mA steps
	(The 50N elements in the 2.5 mA and 50 mA models have a built-in 30 ms security qualifier time delay.)
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary (Steady State pickup)
Time Delay:	0.00–5.00 seconds, 0.01 seconds steps
Pickup/Dropout Time:	<1.5 cycles

Arc-Flash Instantaneous Overcurrent (50PAF, 50NAF)

Pickup Setting Range, A Secondary

5 A Models:	0.50–100.00 A, 0.01 A steps
1 A Models:	0.10–20.00 A, 0.01 A steps
Accuracy:	0 to +10% of setting ±0.02 • I_{NOM} A secondary (Steady State pickup)
Pickup/Dropout Time:	2–5 ms/1 cycle

Arc-Flash Time-Overlight (TOL1–TOL4)

Pickup Setting Range, % of Full Scale:	3.0–20.0%
Pickup/Dropout Time:	2–5 ms/1 cycle

Inverse-Time Overcurrent (51P, 51G, 51N, 51Q)

Pickup Setting Range, A Secondary:

5 A Models:	0.50–16.00 A, 0.01 A steps
1 A Models:	0.10–3.20 A, 0.01 A steps
50 mA Models:	5.0–160.0 mA, 0.1 mA steps
2.5 mA Models:	0.13–2.00 mA, 0.01 mA steps
Accuracy:	±5% of setting ±0.02 • I_{NOM} A secondary (Steady State pickup)
Time Dial	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Accuracy:	±1.5 cycles, ±4% between 2 and 30 multiples of pickup (within rated range of current)

Undervoltage (27)

Setting Range:	Off, 0.02–1.00 • Vnm
Accuracy:	±1% of setting ±0.5 V (±5% of setting ±2 V with the xx71xx card)
Pickup/Dropout Time:	<1.5 cycles

Overvoltage (59, 59G, 59Q)

Setting Range:	Off, 0.02–1.20 • Vnm
Accuracy:	±1% of setting ±0.5 V (± 5% of setting ± 2 V with the xx71xx card)
Pickup/Dropout Time:	<1.5 cycles

Power Elements (32)

Instantaneous/Definite Time, 3 Phase Elements Type:	+W, –W, +VAR, –VAR

Pickup Setting Range, VA Secondary:

5 A Models:	1.0–6500.0 VA, 0.1 VA steps
1 A Models:	0.2–1300.0 VA, 0.1 VA steps
Accuracy:	±0.10 A • (L-L voltage secondary) and ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (5 A nominal) ±0.02 A • (L-L voltage secondary) and ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (1 A nominal)
Pickup/Dropout Time:	<10 cycles

Power Factor (55)

Setting Range:	Off, 0.05–0.99
Accuracy:	±5% of full scale for current ≥ 0.5 • INOM

Frequency (81)

Setting Range:	Off, 20.00–70.00 Hz
Accuracy:	±0.01 Hz (V1 ≥ 60 V) with voltage tracking ±0.05 Hz (I1 ≥ 0.8 • Inom) with current tracking
Pickup/Dropout Time:	<4 cycles

Rate-of-Change of Frequency (81R)

Setting Range:	Off, 0.10–15.00 Hz/s
Accuracy:	±100 mHz/s, ±3.33% of pickup

Synchronism Check (25)

Pickup Range, Secondary Voltage:	0.00–300.00 V
Pickup Accuracy, Secondary Voltage:	±1% ±0.5 volts (over the range of 12.5–300 V)
Slip Frequency Pickup Range:	0.05 Hz–0.50 Hz

Slip Frequency Pickup Accuracy:	±0.05 Hz
Phase Angle Range:	0–80°
Phase Angle Accuracy:	±4°

Synchronism-Check Undervoltage (27S)

Setting Range:	Off, 2.00–300.00 V
Accuracy:	±1% of setting ±0.5 V (over the range of 12.5-300 V)
Pickup/Dropout Time:	<1.5 cycles

Synchronism-Check Overvoltage (59S)

Setting Range:	Off, 2.00–300.00 V
Accuracy:	±1% of setting ±0.5 V (over the range of 12.5-300 V)
Pickup/Dropout Time:	<1.5 cycles

Station Battery Voltage Monitor

Operating Range:	0–350 Vdc (300 Vdc for UL purposes)
Pickup Range:	20.00–300.00 Vdc
Pickup Accuracy:	±2% of setting ±2 Vdc

Timers

Setting Range:	Various
Accuracy:	±0.5% of setting ±1/4 cycle

RTD Protection

Setting Range:	Off, 1–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 ohm max. per lead
Update Rate:	3 s
Noise Immunity on RTD Inputs:	To 1.4 Vac (peak) at 50 Hz or greater frequency

Metering

Accuracies are specified at 20°C, nominal frequency, ac currents within (0.4–20.0) • I_{NOM} A secondary, and ac voltages within 50–250 V secondary unless otherwise noted.

Phase Currents:	±2% of reading, ±2°
3-Phase Average Current:	±2% of reading
Current Imbalance (%):	±2% of reading
IG (Residual Current):	±3% of reading, ±2°
IN (Neutral Current):	±2% of reading, ±2°
3I2 Negative-Sequence Current:	±3% of reading
System Frequency:	±0.01 Hz of reading for frequencies within 20.00–70.00 Hz (V1 > 60 V) with voltage tracking ±0.05 Hz of reading for frequencies within 20.00–70.00 Hz (I1 > 0.8 • Inom) with current tracking
Line-to-Line Voltages:	±1% of reading (±2% with the xx71xx card), ±1° for voltages within 24–264 V

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3 tube kit
Customer.

HVS-C-1512S-J-NASA 15kV Class

Splice for 1/C jacketed Concentric Neutral Power Cables

Product Installation Instructions

Safety Instructions

⚠ DANGER *When installing electrical power system accessories, failure to follow applicable personal safety requirements and written installation instructions could result in fire or explosion and serious or fatal injuries.*

⚠ DANGER *To avoid risk of accidental fire or explosion when using gas torches, always check all connections for leaks before igniting the torch and follow the torch manufacturer's safety instructions.*

⚠ DANGER *To minimize any effect of fumes produced during installation, always provide good ventilation of confined work spaces.*

⚠ DANGER *As TE has no control over field conditions which influence product installation, it is understood that the user must take this into account and apply his own experience and expertise when installing product.*

⚠ DANGER *Working around energized high-voltage systems may cause serious injury or death. Installation should be performed by personnel familiar with good safety practice in handling high-voltage electrical equipment. De-energize and ground all electrical systems before installing product.*

⚠ DANGER *Power distribution and transmission products must be properly selected for the intended application. It must be installed and serviced by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures.*

⚠ DANGER *Read and understand the contents of these instructions before installation and follow all locally approved procedures and safety practices before installing or operating this equipment.*

⚠ CAUTION *These instructions cannot cover all details or variations in the equipment, procedures, or processes described, nor provide directions for meeting every possible contingency during installation, operation, or maintenance. When additional information is desired to satisfy a problem not covered sufficiently for the user's purpose, please contact your TE sales representative. These instructions are not intended to supersede or replace existing safety and operating procedures.*

NOTICE *Upon receipt of a product, inspect it thoroughly for damage and loss of parts incurred during shipment. If damage or loss is discovered, file a claim with the carrier immediately or contact your TE representative.*

Suggested Installation Equipment (not supplied with kit)

- Cable preparation tools
- TE P63 cable preparation kit or cable manufacturer approved solvent
- Clean, lint-free cloths
- Non-conducting abrasive cloth, 120 grit or finer
- Electrician's tape
- Connector(s) and installation tools
- TE recommended torch

Recommended TE Torches

Install heat-shrinkable cable accessories with a "clean burning" torch, i.e., a propane torch that does not deposit conductive contaminants on the product.

Clean burning torches include the TE FH-2629, FH-2649 (uses refillable propane cylinders) and FH-2618A (uses disposable cylinder).

Adjusting the Torch

Adjust regulator and torch as required to provide an overall 12-inch bushy flame. The FH-2629 will be all blue, the other torches will have a 3- to 4-inch yellow tip. Use the yellow tip for shrinking.

Regulator Pressure

FH-2618A	Full pressure
FH-2649	25 psig
FH-2629	15 psig

General Shrinking Instructions

- Apply outer 3- to 4-inch tip of the flame to heat-shrinkable material with a rapid brushing motion
- Keep flame moving to avoid scorching
- Unless otherwise instructed, start shrinking tube at center, working flame around all sides of the tube to apply uniform heat

To determine if a tube has completely recovered, look for the following, especially on the back and underside of the tube:

1. Uniform wall thickness
2. Conformance to substrate
3. No flat spots or chill marks
4. Visible sealant flow if the tube is coated

NOTICE *When installing multiple tubes, make sure that the surface of the last tube is still warm before positioning and shrinking the next tube. If installed tube has cooled, re-heat the entire surface.*

Customer Service

For 24 hour customer service, call 800-327-6996.

Installation Instructions

1. Product selection

Check kit selection with cable diameter dimensions in Table 1.

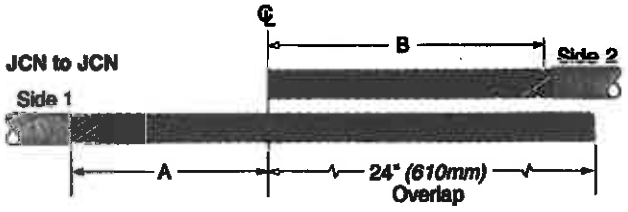
Table 1

Kit	Nominal Cable Range	Insulation Diameter Range	Maximum Connector Dimensions	
			Diameter	Length
HVS-C-1512S-J-NASA	4/0-400 kcmil	0.70-1.30 (18-33mm)	1.17 (30mm)	5.5" (140mm)

2. Prepare cables

JCN

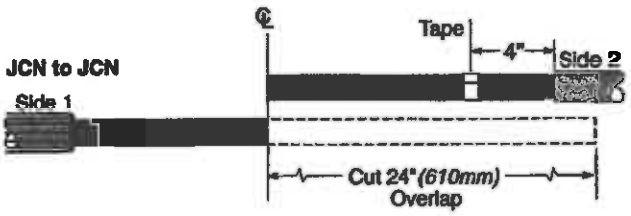
Overlap the two cables as shown. Refer to Table 2 (below) and remove the cable jacket to Dimensions A (plus the 24" overlap) and B.



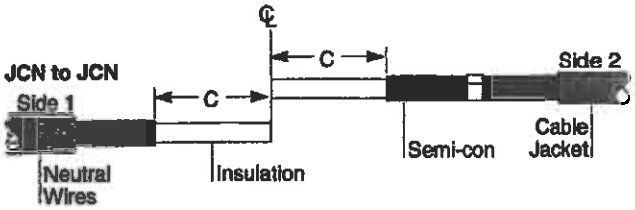
1213

Fold back the neutral wires on Side 1. Trim the neutral wires on Side 2 to 4" and tape over ends as shown.

Cut Side 1 cable at center line.



1214



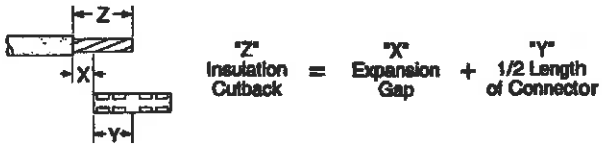
1215

Table 2

Kit	Jacket Cutback A	Jacket Cutback B	Semi-con Cutback C	Maximum Connector Dimensions		Expansion Gap "X"
				Length	Diameter	
Dimensions in inches						
HVS-C-1512S-J-NASA	9"	13"	5.25"	5.5"	1.17"	0.25"

3. Remove insulation

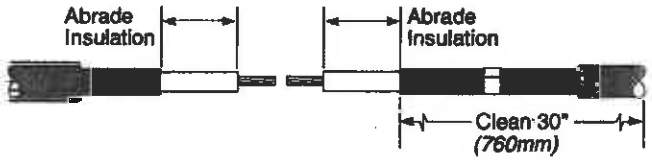
Refer to Table 2 and cut back the insulation as shown.



400

4. Abrade insulation; clean cable

Abrade the insulation, if necessary, to remove imbedded semi-con. Clean cable as shown.

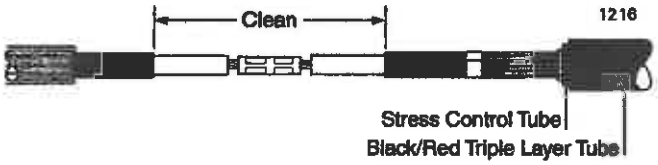


5. Place tubes over cable; install connector

Protect tubes from end of conductor as it is placed over the cable.

Install the connector. After installation, deburr connector.

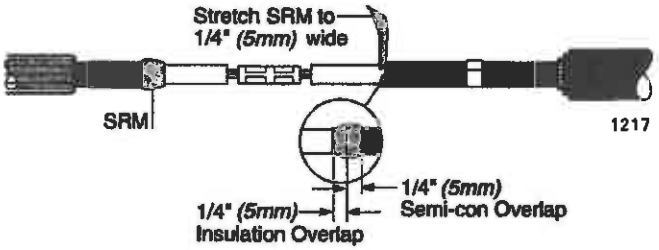
Using an approved solvent, clean the insulation as shown.



6. Apply SRM at semi-con cutback

Remove backings from the short angle-cut piece of SRM. Place tip of SRM at semi-con cutback and tightly wrap to fill semi-con step. Overlap semi-con and insulation as shown. Taper SRM down to meet insulation.

Depending on cable size, more SRM may be supplied than is required to fill the step. After filling the step, discard excess angle-cut pieces.



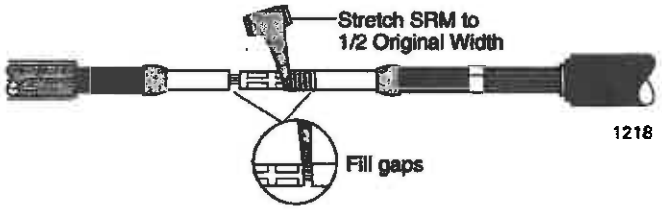
7. Apply SRM over connector

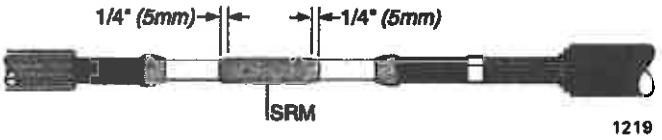
Remove backing from one side of the long strip of Stress Relief Material (SRM). Roll the SRM and remaining backing strip into a convenient size. Removing the remaining backing strip, tightly wrap the SRM around the connector and exposed conductor. Be sure to fill the gaps and low spots around the connector.

Continue to wrap SRM 1/4" (5mm) onto the solvent cleaned insulation as shown (finished SRM diameter should be only slightly larger than that of the cable insulation). It may not be necessary to use all of the SRM.

On cables of differing insulation diameters, SRM should be tapered down from the larger insulation OD to the smaller.

NOTICE *If connector diameter is larger than insulation diameter, apply two tightly wrapped, half-lapped layers of SRM over the entire connector. Discard any excess SRM (long strips).*





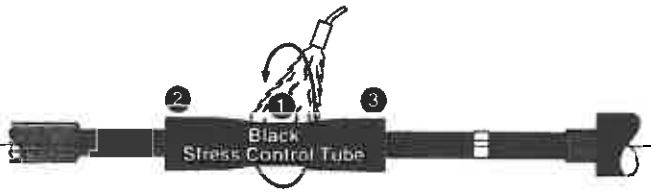
8. Apply Silicone Grease (SG)

Snip open end of the SG ampule and apply a thin film of compound on the SRM over the connector and the semi-con steps.

Apply thin film of SG over surface of installed SRM

9. Position black stress control tube; shrink in place

Center the tube over the splice. Begin shrinking at the center (1) of the tube, working the torch around all sides of the tube. After the center portion shrinks, work towards one end (2), then to the opposite end (3).



1756

NOTICE *Do not point the flame at the cable semi-con.*

Post heat the connector area until the tube surface is smooth and the under-lying SRM wraps are no longer visible.

10. Apply red sealant

Remove release paper from red sealant strip. Fold in half to make 1" wide and place two full wraps onto cable semi-con layer butted up against the black stress control tube

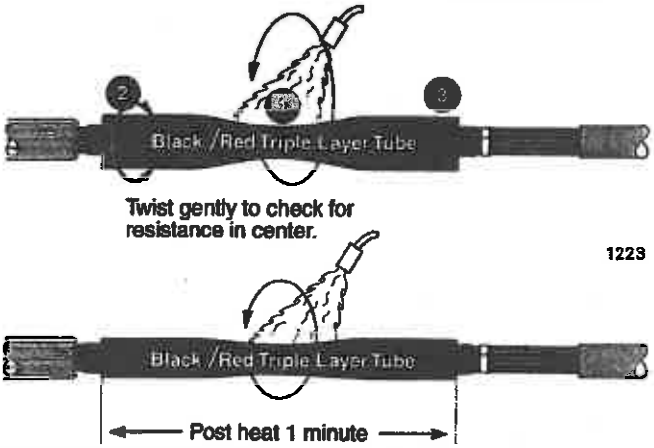
1767

11. Position black/red triple layer tube; shrink in place

Center tube over joint as shown. Begin shrinking at center of tube (1), working torch with a smooth brushing motion around the tube. Before moving away from the center, make sure the tube has shrunk by gently twisting the unshrunk end to feel for resistance. After center portion shrinks, work torch as before toward one end (2), then to the opposite end (3).

NOTICE *Pay particular attention to the hard to reach parts, especially the back and underside of the tube. The tube should have a smooth and even surface when finished.*

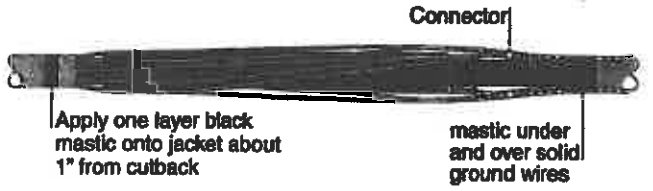
Post heat the entire tube for 1 minute after fully shrunk.



1223

12. Connect nuetral wires nd external solid copper ground wire

Split the concentric neutral wires in half for each end of the cable being spliced. Cut a length of #4 AWG solid bare copper wire that will be long enough when folded in half to go from the splice to the ground grid conductor. Use two barrel crimp connectors (such as the FCI/Burndy YSM28) that are capable of parallel connecting at least 300 kcmil of copper stands. Slide one leg of the #4 AWG solid, and half the concentric neutrals from each side of the splice through the barrel crimp connector. The solid #4 AWG conductor should loop through both connectors and the bend should not be over the triple layer tube. Make sure to trim the excess concentric neutral wires that extend beyond the connectors.



1225

Crimp the connectors.

Use vinyl, friction or rubber tape to cover the crimp and any sharp edges of wire sticking out of the crimp.

Use new black mastic. Abrade 8 inches of cable jacket on each side of the splice. Clean with cable cleaner. Apply two wraps of black sealant mastic on to the jacket starting near the jacket cut back. Press the #4 AWG solid wires into the black mastic and apply tape to the wires to hold them next to the cable jacket. Apply two layers of black mastic over the black mastic and the solid wires as shown.

13. Install the shielding mesh.

Wrap a half-lapped layer of the mesh across the entire splice and tie-off.

Abrade and solvent clean cable jackets as shown to provide an oil-free surface.

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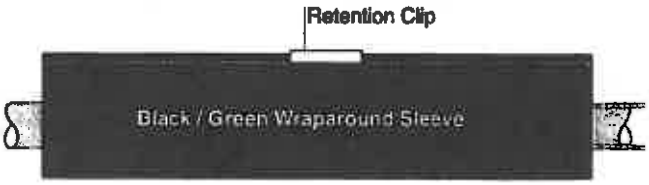
14. Position wraparound sleeve.

Remove or tape over all sharp points to prevent puncture of wraparound sleeve. Remove backing from the wraparound sealing sleeve and center sleeve over splice. Clamp the metal retention clip onto the butted rails at the center of the sleeve to hold the sleeve together while channels are installed.



614b

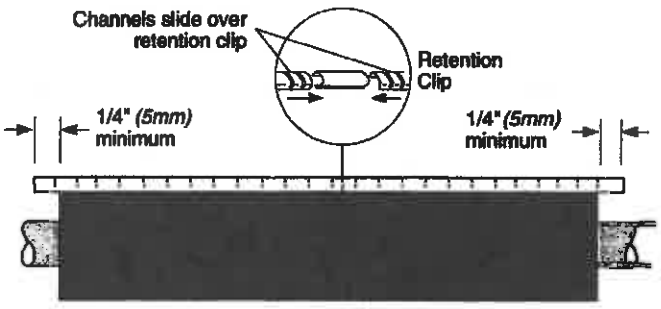
15. Install channels.

Connect the channels by overlapping the retention clip as shown at right.

NOTICE *Channels must overlap sleeve edge by 1/4 inch (5mm) minimum.*

If channels slide on easily go to step 16. If channel fit seems tight, continue with next paragraph.

As shown in illustration A, make sure flap is not pinched between the rails. Push the sleeve up from the bottom and down from the top while sliding on channel as shown in illustration B. The idea is to flatten the rails together to prevent the channels from binding.



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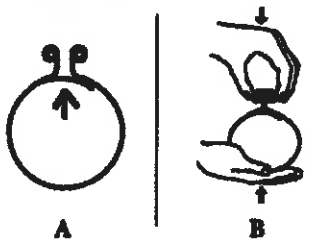
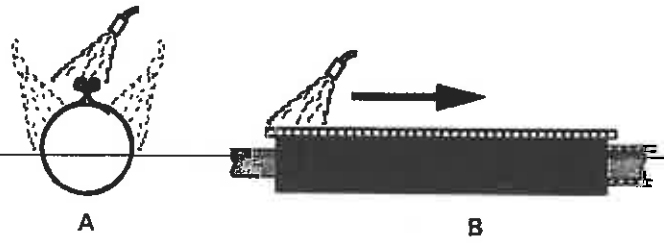
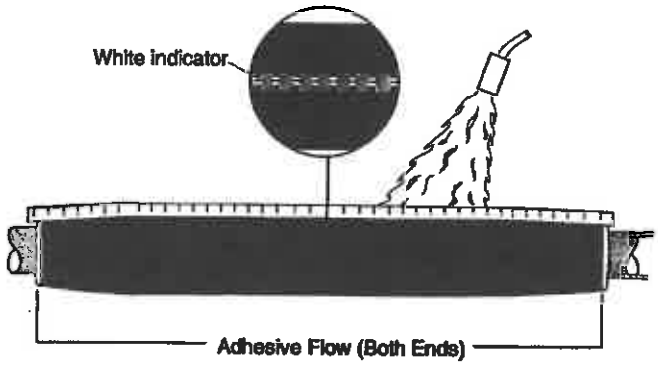


16. Shrink the wraparound sleeve.

Preheat evenly along both sides of the rail/channel area until this area begins to shrink. To achieve uniform heating, move the flame back and forth from one side of the channel to the other as shown in illustration "A" while moving flame along the entire length of the channel as shown in illustration "B" until the sleeve starts to shrink. This technique will assure a properly preheated rail and channel area.



Begin shrinking at the center of the sleeve. After shrinking the entire circumference at the center, then work toward each end. Apply heat until the sleeve is fully shrunk and the heat-sensitive green paint is completely converted to black. Continue heating the rail/channel area for another 5 seconds per foot. A white line should be visible in the channel gaps indicating sufficient heating.



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NOTICE *Green heat-sensitive paint will turn black as sleeve shrinks in place.*

This completes the splice.

NOTICE Allow to cool before moving or placing in service.

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